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INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION

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RESEARCH TO SERVE A GROWING REGION

A program of research aimed at finding solutions to problems as varied and complex as those involved in the management of the forest, range, and watershed lands of the Intermountain region must have both continuity and fluidity. The need for continuing study is evident when it is considered that the wild lands of this region are subject to great climatic variations, the full effects of which on plant growth, soil stability, and stream flow cannot be accurately determined except over a long period of years. The need for occasional shift of emphasis and direction of research is also understandable when economic change brings about new or increased demands for the resources and services of the wild lands.

The economy of the Intermountain region is now undergoing a substantial expansion. The evidence is to be seen in many places. Practically everyone of the 315 cities and communities in the region has had to build new homes, new offices, and improve water and sewage systems to accommodate 25 percent more people than there were a decade ago. On the outskirts of these communities are new refineries, factories, and warehouses. Extending out from these population centers are new pipelines to tap vast, newly developed gas and oil fields; new transmission lines to carry an enlarged electric power supply; and new access roads to recently discovered and as yet only partially developed deposits of phosphate, uranium, and other strategic minerals. Coming out of the mountains also are new canals and pipelines for carrying water from many large reservoirs to irrigated farms, hydroelectric plants, factories, and homes.

These developments have had a direct and powerful impact on the 165 million acres of forest and range lands in the region. A greatly increased demand for lumber has pushed logging operations into steeper and more remote forest lands for which there are no reliable management guides. Increased demands for meat--venison and elk as well as beef, mutton, and lamb--have further accentuated a serious range problem of long standing. In the face of these mounting pressures for greater utilization of the timber and forage resources of the wild lands, problems of maintaining soil stability and control of storm runoff on steep slopes above reservoirs, power plants, and communities have become increasingly serious and difficult to solve.

During the past year two separate appraisals were made of the wild land problems and the Station's research program. One was limited to consideration of research needs in the Intermountain portion of the Columbia River Basin. This inquiry revealed the need for a 4- to 5-fold expansion of research in forest, range, and watershed research and for much more economic information about the forest and range resources. The second effort involved a region-wide reappraisal of each of the functional lines of research currently under way. This inquiry indicated some desirable changes in emphasis and scope of work within the limits of present funds and personnel.

Several changes have already been made in the Station program. The effort on forest management research has been substantially increased by the initiation of the forest survey in Idaho and by a comprehensive analysis of problems on lodgepole pine lands. Watershed research has been extended to include a study of the effects of logging disturbance on sediment production in ponderosa pine and further study of water conservation on the range. Effort on flood control surveys was curtailed in midyear because of reduction in funds. Some additional studies in forest, range, and watershed management are being planned by extension of cooperative aid to three of the universities in the region.

The following sections of this report give further details about the wildland problems of the region, the current research on those problems, some of the current findings, and plans for the coming year.

RANGE RESEARCH IN THE INTERMOUNTAIN REGION

The region served by the Intermountain Forest and Range Experiment Station includes Utah, Nevada, Idaho south of the Salmon River, southwestern Wyoming, and very small parts of Colorado and California. The total area is approximately 180 million acres, of which about 140 million is range.

Hardly any other area in the United States is so variable in the character of its terrain, for the Intermountain region includes parts of six physiographic provinces.

The Intermountain climate is prevailingly arid, except in the mountains. Annual precipitation varies from less than 5 inches at the eastern base of the Sierra Nevada to 40 inches or more at elevations above 9,000 feet in northern Utah. Snowfall in the mountains is responsible for yearlong stream flow, but summer storms cause most of the accelerated erosion and may give rise to flash floods.

Vegetation of the most arid lowlands is salt-desert shrub, the largest type being shadscale-winterfat. This is livestock winter range. Sagebrush-grass, the largest type in the region, together with juniper-pinyon and the lower part of the mountain brush type, occupy the mountain valleys and foothills and furnish forage for livestock in spring and for big game in winter. Mountain brush and forest types form summer range for both livestock and big game. These sloping, water yielding mountain lands are highly susceptible to erosion when plant cover is damaged or destroyed.

Settlement of the Intermountain region began about 100 years ago. Towns and farmsteads were located either on the rivers, as along the Snake in southern Idaho, or at the mouths of streams issuing from the mountains. The population in 1950 was 1-1/3 million, which includes an increase of 22.6 percent over 1940.

Since early settlement livestock production has been a basic industry. In 1950 there were a million beef cattle and nearly 2-1/2 million sheep in the Intermountain region. Most of these animals graze at least part of the year on range land. The value of livestock and livestock products (other than dairy and poultry) sold in 1949 was $171 million. This was greater than the value of crops sold.

Big game graze in most of the mountains and foothills, and antelope graze some of the lowlands. Total estimates for the region are not available, but in 1951 big game on national forests were estimated at more than half a million, as follows:

Deer	436,000	Moose	3,700
Elk	49,000	Bighorn sheep	3,200
Antelope	8,900	Mountain goat	2,300

Utah alone sold 120,797 big game hunting licenses in 1951 and harvested 101,494 deer and 1,507 elk.

RANGE PROBLEMS OF THE INTERMOUNTAIN REGION

Over-all Problem

The most universal land use in the Intermountain region, during most of the 100 years since settlement, has been livestock grazing. Practically the entire area has been overgrazed in one way or another, and as a result there is one over-all problem in range management--that of rehabilitating depleted vegetation and deteriorated sites. Much improvement has taken place under the regulations that have been imposed on grazing in the last 50 years, but even where improvement has occurred it is usually far from adequate. The need for rehabilitation applies to vast areas--desert lands, sagebrush plains and foothills, mountain brush types, forest types of various kinds, and mountain grasslands. On practically the entire grazable area of the region, irrespective of type, vegetation has been depleted by abuse, and soil has been eroded in greater or less degree.

Although nearly all vegetation has changed in the same direction, the specific character of change varies with vegetal type. In each type the change involves both reduction or elimination of desirable forage plants and increase of less desirable plants.

Where the desirable forage plants are woody, like black sage, bud sage, and winterfat in the salt-desert shrub association, or bitterbrush or cliffrose in the sagebrush association, remnants of the original forage plants may persist. Usually these have been weakened and mutilated by grazing animals. In some cases the plants are so tall that their crowns escape grazing. As a rule these woody plants are old, with little current reproduction in evidence. Nevertheless, a residual stand of desirable species provides a seed source, and the management problem may be chiefly one of lessening grazing pressures so that young plants can become established.

On the other hand, where the desirable forage plants are herbaceous, the problem is likely to be more difficult. If grazing has been very severe, these desirable species may have been largely eliminated, and the seed source, if any, is likely to be small and poorly distributed. The first natural improvement must come, therefore, not from the most desirable species, but from those of lesser value that are still present in the stand. This appears to be the situation in many foothill and mountain types. Whatever the seed source of desirable species, an increase or an invasion of undesirable plants such as sagebrush, cheatgrass, or tarweed, retards the natural increase of desirable ones. The greater the proportion of undesirable plants, the greater the rehabilitation cost, reckoned either in cash outlays for removing undesirable plants and for artificial seeding, or reckoned in time--a long time, usually--for natural recovery.

Even more serious than the loss in grazing value from adverse changes in vegetal composition are the effects of thinning the cover so that accelerated erosion has gotten under way, or the introduction of a new kind of cover which is less effective than the original cover in preventing erosion--cheatgrass, because of its inflammability, is a case in point. Erosional problems as a result of overgrazing vary greatly from site to site, but they are widespread in the Intermountain region.

To anyone unfamiliar with the West the solution is easy: simply eliminate all grazing for awhile and let the ranges recover. This course, if carried to its logical conclusion, would also necessitate elimination of big game, for in many areas unnaturally high populations of deer or elk have contributed to range depletion, and in some places they have been the principal cause. Under complete protection from grazing, however, with all the economic loss and disruption of western cultural values that such a "solution" would require, some ranges would take an impracticably long time recovering--probably several human lifetimes, and on some rest alone would not bring about recovery. Clearly, therefore, this sweeping, "easy solution" of the problem of range depletion is no solution at all.

In the first place, each area of range is different and must therefore be improved on the basis of its own condition and its own potentialities. The great majority of ranges may be expected to respond to simple management practices. Many others will require more costly measures such as artificial seeding, water development, and fencing. On still others--harsh, deteriorated sites--rehabilitation is likely to be very difficult and may be even more costly than the grazing value of the land would warrant. Such badly deteriorated areas, which may have great value from the watershed point of view, are fortunately small in relation to the total area of western range land. For these reasons the problem of range restoration, generally speaking, is not one of eliminating grazing; it is one of restoration under use.

When the problem of widespread range deterioration is examined more closely--when one gets down to specific types and sites, specific degrees of deterioration, specific kinds of animal use, and the like--it becomes evident that more knowledge is needed to do the management job. This is where research comes in. It is true that materially better management could be had on practically all Intermountain range lands if facts and principles already known were more generally applied. Lack of research knowledge is hardly a valid reason for continuing to overgraze depleted range where it is obvious that vegetal cover is insufficient to protect the soil or where it is obvious that desirable forage species are losing ground. But there are many ranges where condition is not so obvious and where trend is not so easily seen. Here are many questions that need to be answered before more than tentative steps in management can be taken. And even where the first step can now be taken with assurance, what about the next step in management? What is the ultimate goal? The function of range research is to answer these questions for specific types and sites.

Special Problem Areas

Recognizing that the problem of range deterioration is widespread, it is still possible to specify three general problem areas where need for research appears most urgent.

Mountain grasslands

The first are mountain grasslands, ranging from herbaceous vegetation in the alpine and subalpine zones down to herbaceous openings in forest or shrub communities at lower elevations. These herbaceous types are not localized, but occur in the mountains throughout the region. They are of particular concern in the improvement of national forest ranges for more effective watershed protection. Because certain slopes have been denuded of their herbaceous cover by overgrazing, mud-rock flows have occurred in some places. However, even where considerable soil stability has been achieved as a result of increasing vegetation, and where mud-rock flows occur only rarely at present (as above Mt. Pleasant in central Utah), accelerated erosion continues apace and sites continue to deteriorate. Techniques for rehabilitating many of these slopes are still to be developed. Probably many of them will require extensive artificial seeding. Even using the best means now known, there is still the possibility that some of these soils are no longer deep enough to support sufficient vegetation to protect themselves against erosion. This problem of the stabilization of mountain soils is clearly one of the utmost urgency.

Granitic soils of southwestern Idaho and the eastern front of the Sierra Nevada

The second problem area is on granitic soils where slopes are steep. The problems of accelerated erosion are intensified here by a soil that is naturally droughty and loose, and abnormally so now because of the loss of fine materials through accelerated erosion. The causes for this condition are a combination of overgrazing, invasion of cheatgrass, and repeated fire. The results are not only a continuing deterioration of soils on the slopes, but continuing siltation of downstream irrigation works. The costs of this siltation, as well as continuing watershed deterioration, make it imperative that rehabilitation be undertaken. However, little is known about rehabilitation, either natural or artificial, of vegetation on these granitic soils.

Colorado River Basin

The third problem area is the drainage of the Colorado River. These range lands constitute a problem because of the silt they contribute, particularly from desert and semidesert lands, to the Colorado. The importance of the Colorado River in developing irrigation and power, in Wyoming, Utah, Colorado, Nevada, Arizona, and California, is very great. There is considerable information available in corresponding types in other parts of the Intermountain region, and perhaps also from adjacent regions, which would apply to the siltation problem of the Colorado River drainage. However extensive studies in the basin of the Colorado itself are lacking, and until on-the-ground study is made, specific technical problems cannot be understood, and known principles cannot be properly applied.

Special Problems

Certain kinds of problems extend across problem area boundaries, and indeed over most of the range lands of the region. For convenience these will be considered under rather broad headings, the ecological basis for management, criteria for judging range condition and trend, influence of animals in the range complex, control of undesirable plants, artificial seeding for forage and cover, and species and methods for harsh sites. Only the most important specific phases of these problems can be described here.

Ecological basis for management

Ecological research upon which studies directly applicable to range management are based, constitute this special problem. Such research includes studies of the distribution of plant populations both in space and in time, community structure, phenological and growth characteristics of individual species, environmental requirements for successful establishment, both of naturally and artificially seeded species, and interrelations between plant behavior and habitat factors.

One cannot go far toward an understanding of the response of vegetation to grazing without improving his understanding of reactions of the individual plant, not only to grazing but to numerous other environmental factors--the kind of soil, the incidence of moisture and of radiation, and the kinds of plants with which it is associated. There are many problems of a physiological nature, for example, in getting successful germination of seeds, particularly seeds of some native shrubs. As another example, more detailed knowledge of periods of growth, both above and below ground, and the concurrent processes going on inside the plant, would help greatly in understanding the mechanics of competition between the plant and other plants nearby, and the effects of grazing on translocation by the plant of the food it manufactures.

The fundamental research most urgently needed, however, is that which will increase our knowledge of the vegetation and soil of normal range. Whatever the range owner or administrator does by way of technical management on a given site, he is guided, for better or worse, by his conception of what is normal for that site. He is often guided for worse rather than for better, at present, because his conceptions of normal productive potential and normal erosion characteristics are often wrong. They are wrong for the reason that his experience has been, not with virgin range, but with range that is greatly changed, now depleted and deteriorated by 75 to 100 years of grazing. Where studies have been made to reconstruct the original native vegetation, as at the Desert Experimental Range and in the subalpine zone of the Wasatch Plateau, the results have shown that the productivity potential of the range and its normal soil stability are much greater than those who dealt only with the open range were able to imagine. There is every indication, from natural areas, exclosures, and artificial seeding trials, that for ranges between these environmental extremes the same thing is true.

Part of the effort in fundamental research to improve our concepts of the normal lies in working out normal processes of change. These include normal plant succession and soil development. One important application of such knowledge is that it serves as a standard for evaluating present-day trends caused by grazing, rodents, climate, and other factors in the range complex.

The reason why an understanding of the normal--vegetation, erosion, and developmental processes--is so urgent is that a factual basis is needed by land managers for judging present range condition and for inferring the character and velocity of range trend. The greater the factual basis for these judgments, the more rapidly range management will improve: fundamental ecological research is the key to more effective management.

Criteria for judging range condition and trend

Condition and trend studies are possible in some areas on the basis of what we already know about the ecology of the vegetation. In other areas intensive ecological research is necessary before reasonably reliable indicators of condition and trend can be established. Nevertheless, because of the widespread character of the problem and the necessity to take effective action before much more deterioration occurs, condition and trend studies should be made as quickly as possible and at practicable levels of intensity for every major type. Their value, of course, will vary according to the soundness of their basis in an understanding of normal vegetation and soil, as outlined in the preceding section. It is therefore highly desirable that effort on such "quickie" studies should be balanced by basic ecological research to deepen and improve this understanding of the normal, and that the first criteria of condition and trend be revised as new knowledge is gained.

At the same time that information is gathered on condition and trend, either by fundamental ecological studies or by "quickie" methods, facts on rate of change in various condition classes, under various treatments, need to be collected. Fortunately there are a number of old study areas in various parts of the Intermountain region that provide records of range condition years ago. These records, if systematically studied in the field, with due allowance for their imperfections, would give many valuable clues to range trends. The amount of change to be expected in a given time under certain grazing pressures needs to be known, and those areas where lessening grazing pressure will be effective in rehabilitation need to be distinguished from those requiring cultural measures, such as clearing, burning, planting, and the like. For example, on some ranges that look badly beaten as a result of current grazing, the conclusion can be reached that artificial seeding is the needed remedy, when in fact a native seed source exists that is adequate for natural recovery under improved management. If in this case appropriate indicators were to be discovered and the needed management inferred, unnecessary costs in rehabilitation could be avoided.

Influence of animals in the range complex

The effects of grazing at different intensities, different seasons, and by different classes of animals are of course among the principal questions that range research needs to explore, and much of the effort of the division is directed toward answering them. Pasture studies where grazing is carefully controlled are under way with sheep at the U. S. Sheep Experiment Station, Dubois, Idaho, at the Desert Experimental Range, Milford, Utah, and on seeded range at Ephraim, Utah. Similar pasture studies with cattle are under way on seeded range at Benmore, Utah. There are, in addition, a number of less formal studies on both native and seeded range, with cattle and with sheep in other places in the Intermountain region, and with deer, alone and in combination with sheep and cattle, in Utah. The purpose of these studies is to develop and test systems of grazing and other management techniques for improvement of the range. They also lend themselves to development of criteria of condition, trend, and proper utilization.

The effects of grazing on other animals, and the influence of other animals on the range, need more attention than we have been able to give. The range needs and competitive relations of big game other than deer, particularly elk in southwestern Wyoming, are little understood, but they are involved in serious problems of range and watershed management. A seemingly simple and important need, but one that appears to be a long way from being met satisfactorily, is the ability to tell, from the appearance of a range, what part of the grazing has been done by domestic livestock and what part by wildlife. The effects of insects on the range are becoming recognized as much more important than we have been accustomed to believe, and their interrelations with grazing are sorely in need of scientific study. At present two small cooperative studies on the influence of pocket gophers on subalpine vegetation are under way in Utah. Parts of several exclosures on desert range in Nevada are built to exclude small mammals as well as livestock, and data collected on these in 1947 are in process of analysis.

The coverage of these studies is very incomplete. Construction of elaborate pastures for controlled grazing experiments cannot be extended very rapidly because initial costs are high and maintenance becomes a burden. Broader areal coverage by studies on the influence of animals can at present be achieved only by extensive studies and by comparisons between exclosures and grazed range.

Control of undesirable plants

Undesirable plants that have increased on Intermountain ranges include sagebrush, rabbitbrush, cheatgrass, tarweed, wyethia, pinyon-juniper, and a number of poisonous species such as halogeton, larkspur, lupine, and sneezeweed. Procedures for the control of some of these species are known. Tarweed dominance, which used to cause consistent failures in range seeding--so consistent, in fact, that it was believed there was something wrong with the soil supporting tarweed--can now be controlled successfully by plowing at the right time of year and seeding adapted grasses. Much progress has been made in the use of fire and mechanical methods in eradicating sagebrush so as to increase the production of herbaceous vegetation. Simply lessening the intensity of grazing on sagebrush range will ultimately produce results, but because of the longevity of sagebrush, the trend toward improvement is slow.

Where pinyon and juniper have invaded sites with deep soil, such improvement is likely to be even slower, for the trees will evidently outlive many generations of men. Where ground fuels are sufficiently abundant fire would appear to be a solution. So little research has been done on the ecology of this important type, however, that a discussion of control at this time is premature.

A big help in approaching the problem of juniper invasion would be afforded by an understanding of the reasons underlying it. Evidently this invasion is a new thing, and it is probably related to disturbance of the range complex since the advent of white men; but what kind of disturbance? Overgrazing, lessening of fire, activities of rodents, or what? The kind of ecological understanding needed for juniper is paralleled by similar needs for other plants we would like to control. We can eradicate sagebrush successfully, but we cannot always be sure that the stand of seeded grass won't be full of sagebrush seedlings. When this happens the sagebrush grows up in a few years and suppresses the grass. If we knew more about the life history of sagebrush, in other words--and the same is true for rabbitbrush and other undesirable species--our efforts at control would probably be more effective and less costly.

A lessening of grazing intensity to encourage native perennial herbs and grasses, coupled with spraying and artificial seeding in badly depleted areas may be a practical solution to the halogeton problem. At any rate Russianthistle, which appears to be similar to halogeton in growth form and requirements, has been essentially eliminated under moderate grazing, as compared with heavy grazing, on desert shrub types. Probably a small, short-term study of the halogeton problem would yield the information necessary to make practical recommendations for control of this deadly weed. The fact remains, however, that there is still much to learn about halogeton, and it may well have peculiarities, such as the ability to occupy salt flats where native vegetation cannot live, which will make its control extremely difficult. Our experimental facilities at Benmore and the Desert Experimental

Range should soon provide excellent opportunities for research on halogeton invasion in relation to time and intensity of controlled grazing. Halogeton has now spread to the edges of both experimental ranges.

A problem has arisen concerning the eradication of the native blackbrush (Coleogyne) which covers large areas in southern Nevada and Utah, sometimes to the virtual exclusion of other vegetation. Some people have become convinced that blackbrush should be burned off to encourage herbaceous vegetation, and without much knowledge about the ultimate consequences, in terms either of range vegetation or watershed cover, large-scale burning has begun. At the request of the Bureau of Land Management members of the Intermountain Station have inspected burns in southern Nevada and made some small experimental seedings of perennial grasses. Our conclusion has been that there is no easy answer to the question of blackbrush burning. In some areas there appears to be benefits--a very marked increase of forage (this is the inducement for burning) and little erosion hazard. In other areas there may be an immediate increase in forage, but long-time forage values are damaged and erosion is very greatly increased. A great variety of combinations of effects has been observed. The pressures for burning are strong, and it is possible that grave and costly damage may be done, in the form of soil erosion and reservoir siltation, if burning is continued blindly as it has been in the past. Thoroughgoing research on the ecology of blackbrush in the great variety of sites in which it grows, and the response of blackbrush and associated vegetation to fire, together with the effects of burning on soil erosion, is urgently needed.

Undoubtedly the most perplexing and important undesirable plant is cheatgrass. Aided by fire, cheatgrass is dominating more and more territory every year in northern Nevada, northern Utah, and particularly in southern Idaho. Its area of dominance is increasing year by year, and with repeated fire its suppression of native vegetation--perennial grasses, forbs, shrubs, and even trees--becomes more and more absolute. Spreading from abandoned dry farms it has swept in the wake of fires over vast areas of sagebrush-grass range up into the foothills, superseding mountain brush, thus limiting game winter range in places, and pushing timber back up the slopes. Drying out like tinder in summer, cheatgrass is a precursor of ever more frequent fires, and with each fire the chances for recovery by perennial species become less and less. Thus to all intents and purposes the spread of cheatgrass is irreversible. Whatever its merits, cheatgrass is tinder for another fire, and because it thus destroys perennial vegetation in its path and bares the ground to accelerated erosion its spread is an ecological catastrophe.

A good beginning has been made in learning how to seed perennials into cheatgrass successfully. Because of cost, artificial seeding can be only a small part of the answer, however. Something that is cheaper and that is applicable on a wider scale is needed, and the way to such a solution, if there is a solution, lies in a better understanding of cheatgrass and the environment in which it is spreading. The necessary research should begin on the advancing cheatgrass front to determine the factors that encourage and that hinder cheatgrass, and how these factors affect native vegetation. It should include studies of the growth requirements of cheatgrass in relation to those of native species. Both on this advancing front and where cheatgrass is already dominant this research should include an appraisal of the effects of grazing management on reinvasion of perennials, maintanance of the cheatgrass forage crop, and fire hazard.

Artificial seeding for forage and soil cover

Much progress has been made in artificial revegetation, particularly on sites having deep soil and precipitation greater than 10 or 12 inches. Where dense, unproductive sagebrush baffled efforts at revegetation 30 years ago there are now stands of waving grass. Hundreds of species have been tested, and methods of brush control and seeding have been developed, until we now know how to write the prescription for practical revegetation of the better sites on depleted sagebrush, mountain brush, aspen, and subalpine lands.

Nevertheless a great deal remains to be done. New species are being tested continually, and efforts to develop more effective, less costly methods are being tried. Trials are being made of selected strains (in cooperation with BPISAE and SCS), for it has been learned that enormous differences in productivity and growth form exist in species adapted to range seeding. A particularly urgent need is for adapted legumes, both to increase the nutritive value of forage and to build up soil nitrogen, and some progress is being made with introduced legumes in areas of fairly high rainfall. Another need is to ascertain whether mixtures of seeded species serve the needs of management better than pure stands, and, if so, what combinations of species are best for particular conditions. Finally there is a pressing need to continue the search, which has already given promising leads, for methods of seeding browse species on depleted big game winter range.

Species and methods of planting for harsh sites

The decision was made early in work on artificial revegetation to concentrate initial efforts on productive sites where chances of success seemed most promising, leaving poorer sites and more difficult problems until later. This has proved to be sound strategy so far, and the results of the last 20 years have exceeded all expectations. There are urgent problems, however, particularly in revegetating steep, eroding slopes where soils are thin, that have been neglected overlong and that should be attacked without delay. The question is one, with limited resources and problems crying for attention on every hand, of striking a reasonable balance between continuing work on the better sites and stepping up work on the poorer ones. This means sacrificing emphasis on sites where immediate dollar values are likely to be found for the sake of emphasis on sites where long-term values, like the soil itself, are at stake.

Soils that have been greatly eroded provide a variety of difficult problems. Usually it is not lack of soil nutrients that makes establishment of vegetation so uncertain as it is the physical nature of the soil. The soil may be hard and unyielding, baking and cracking in summer and likely to uproot seedlings by frost heaving in winter. Or, on the other hand, the soil may be loose and unstable, providing insecure rooting and holding so little water that seedlings die of summer drought. Sometimes soils are refractory even though they have not been greatly eroded, as in skid trails and road cuts and fills. On some, particularly some desert soils, crusts form that prevent emergence of seedlings. Research on the effects of cultural treatments, mulches, detergents, and soil conditioners, all as adjuncts to seeding, is needed to cope with these problem soils.

The replacement of low-value vegetation on saline and alkaline soils by good forage species is a related problem. Considerable progress has been made in finding suitable methods and palatable, highly productive species on such soils where there is a fairly high water table. We have had little success with the drier saline and alkaline soils, however.

Problems of difficult soils are, more often than not, problems of soil drought. This is as true of the granitic soils of southern Idaho and the eastern front of the Sierra as it is of the heavy clays in the upper reaches of the Colorado River Basin and the very sandy soils in the lower portion. Such soil drought is of course intensified by climatic drought where rainfall is scarce. Rainfall is so scarce in much of the Intermountain region, a large part of which receives only between 4 and 10 inches annually, that artificial seeding is precarious even on soils of reasonably good texture and depth. Fortunately most of these depleted desert ranges can recover naturally if the native vegetation is given a chance. Such recovery has been demonstrated under management at the Desert Experimental Range and elsewhere. Nevertheless there are many areas around watering places, stock trails, bed grounds, etc., where native perennial plants have been destroyed, that are in need of artificial seeding. The need is becoming more urgent with increasing recognition of the problem of sediment control and with the invasion of halogeton, but suitable species and methods have still to be developed.

RANGE RESEARCH PROGRAM

Present Effort

In order to understand our present research effort a thumbnail sketch of the background for each of the projects will be included. Because range livestock grazing in this region is seasonal, the first three grazing management projects activated at the Intermountain Station were called summer, spring-fall, and winter range studies. The utilization standards project came into the picture in the late 30's, and the big game-livestock range relationship project, which concerns itself with deer in Utah, in 1946. Research in artificial revegetation goes back to the very beginnings of the Intermountain Station. In the early days experiments were confined largely to the higher elevations in central Utah. About 1925 studies were extended to the lower mountain zones still only in central Utah. In 1935 the artificial revegetation project was strengthened and rejuvenated, and studies in most of the major plant types throughout the region were undertaken.

Summer range

Summer range research began at the Great Basin Branch Station near Ephraim, Utah, about 1911, and we are still following changes in vegetation there on permanent plots that were established in 1913. Most summer range studies have been confined to this locality. Relations between weather and plant growth, variation in climate with topography, microclimate, relations between plant cover and erosion, influences of pocket gophers, carbohydrate translocation in forage plants, and indicators of condition and trend, have been the main interests in this project. Most of the studies are conducted either on open range or on areas protected entirely from grazing. An extensive ecological study of the subalpine zone of the Wasatch Plateau has recently been completed. This study, utilizing old photographs, study plots, and all available natural areas, classifies the plant communities and traces the courses of primary and secondary succession. The highlights of this study are given in the Intermountain Station Annual Report for 1947. The full report is now being prepared for publication.

At present field work on this project is virtually at a standstill for lack of personnel.

Spring-fall range (two men)

Studies of spring-fall ranges of southern Idaho were begun at the U. S. Sheep Experiment Station near Dubois in 1923. The main effort here has been with sheep in pasture studies, and aspects of these studies have been reported. In 1941 a grazing intensity study was begun under a rotation plan. This has now gone through two complete 4-year rotations. The pastures were inventoried in 1949, and the data are now being compiled and analyzed. It is particularly important at this time that we examine the pasture experiments critically to learn whether they are yielding information applicable to major land-use problems. If they are, well and good. If they are not, we should modify them; and if this is not possible we may have to abandon them and apply that research effort to more urgent problems.

The use of fire for range improvement in removing sagebrush has been studied for a good many years at the Sheep Station. The results of these studies have been reported in Farmers' Bulletin 1948, "Sagebrush Burning--Good and Bad." In 1948 a reinventory was made of a controlled burn on which experimental plots had been established in 1932. The results of this reinventory are contained in a manuscript, "Ecological Effects of Planned Burning of Sagebrush-Grass Range on the Upper Snake River Plains," now submitted for Departmental publication.

In the light of this and other knowledge gained during the past 10 years, it is planned to revise and bring up to date the earlier Farmers' Bulletin during 1953.

In addition to these two studies there are many data in the project files which need to be analyzed and reported on. In order to move this work of compilation, analysis, and writing along as rapidly as possible, field work is being kept to a bare minimum for the next two or three years.

Winter range (two men)

In 1933 the Desert Experimental Range was established 50 miles west of Milford, Utah, to provide information for formulating standards of management and proper use on winter range. Studies were begun on utilization, grazing capacity, herbage yield, plant growth, and watering livestock; and in addition sheep and wool weights were obtained to determine the effects of management practices on animal production. A manuscript has been submitted for publication as a Departmental circular covering these studies entitled, "Increasing Forage Yields and Sheep Production on Intermountain Winter Ranges."

In cooperation with the Bureau of Land Management and Forest Service Administration, a series of large exclosures was established in Nevada and parts of Utah in the period 1936 to 1941. Plots inside these exclosures and outside have been examined at roughly 5-year intervals in cooperation with the University of Nevada. One of the major jobs that needs doing at present is analysis of the accumulated data from these plots.

In addition there is a considerable body of accumulated data on the winter range project which has not yet been analyzed. As with the spring-fall project, field work on winter range is being held to a bare minimum in order to give as much time as possible to analysis of data and preparation of manuscripts. Here, too, a reappraisal of the Desert pasture studies in regard to their applicability to urgent winter range problems is very much in order.

Utilization standards (one man)

Most of the work of the utilization standards project has been carried on in the vicinity of the Great Basin Branch Station near Ephraim. This work has been concerned with growth form and measurement of forage utilization, and with an attempt to relate plant vigor to intensity of grazing.

In the past few years the work of the utilization standards project has been redirected to a study of condition and trend. The aspen type in Utah was selected for this study because its grazing potential appeared to be high, general depletion was advanced, and little was known about the type. A good many facts have been learned about the aspen type which should be of help to Administration in management, but progress has been slow in organizing this material partly because of shifts in personnel. It is hoped to get out a guide, at least in preliminary form, by next year.

Field observation suggests that key areas in management may be the openings in the aspen type, and one of the questions that needs to be answered in judging condition concerns the productivity of vegetation in openings as compared with that of vegetation beneath the aspen canopy. Extensive observation has not provided adequate answers to this question, and therefore a short-term experiment is being performed in which the production of several native species is being measured in both environments. Results to date indicate that the potential productivity in openings is fully as great as under the aspen canopy. If this fact is verified, relative production in openings and under the aspen overstory may well prove to be an effective means of appraising range condition.

Big game-livestock range relationships (two men)

This cooperative project involving the Fish and Wildlife Service, Utah State Agricultural College and Experiment Station, Utah State Fish and Game Department, and the Intermountain Station, was begun in 1946.

From the activation of the project until 1950 the efforts of the Intermountain Station were directed principally toward investigation of deer and livestock food-habit relationships, completion of a detailed problem analysis, and preparation of a popular bulletin presenting factual information concerning game and range problems. The problem analysis and the bulletin were completed in 1950 and published as Station Research Paper No. 24 and Publication No. 2 of the Utah Fish and Game Department, respectively. Most of the information obtained from deer-livestock studies has also been published, part has been submitted for publication, and part is now being prepared for publication. Additional work remains to be done on the early spring forage habits of deer.

During the field season of 1950 emphasis was shifted from food habit studies to two other major problems: (1) investigation of proper use of some important forage species, and (2) establishment of criteria for determination of condition and trend on game range. These have not yet provided sufficient information to justify conclusions.

Artificial revegetation (five men)

Attempts at seeding depleted range artificially were made when the national forests were first organized. Early workers saw a need for seeding only badly depleted spots such as bedgrounds and trails where native vegetation had been destroyed and erosion was conspicuous. Natural revegetation, even with complete protection, is slow on such areas, and artificial revegetation was attempted to hasten recovery.

Early workers advised against trying to use cultivated species, foreseeing only a limited use for them, but many early trials included eastern pasture species such as Kentucky bluegrass, timothy, and smooth brome. Among native plants, both grasses and forbs were studied in the belief that species high in the order of plant succession should be favored in restoring depleted range, eliminating those species regarded as part of intermediate stages. It was also believed that the area on national forests susceptible to seeding was so small that seeding operations would never be extensive.

Subsequent research enlarged the scope of artificial seeding and developed new concepts: the need for covering seed, for elimination of competition, for seedbed preparation, for protection of young stands from grazing, the general superiority of certain species on certain sites, and of fall as a time for seeding. Because of the introduction of new species, development of better equipment and more complete information on techniques and procedures, the possibilities of artificial revegetation are now seen to be much greater than was formerly supposed, and extensive areas on the forests and elsewhere have been seeded. To date the national forests in Region 4 have seeded a third of a million acres. Besides "sore spots," extensive areas are now seeded to increase the volume of forage for livestock and to relieve grazing pressure on critical areas elsewhere. But seeding on national forests is only a small part of the total effort: several times that acreage in private and public lands within the Intermountain region have been seeded with reasonable success to date. Much of the know-how for doing this work is based on research by the Intermountain Station.

At present research on artificial revegetation is under way at all branch stations and at numerous other places in all states within the region. This research has developed along natural lines including species adaptability, methods of planting, methods of eliminating competing vegetation, site factors, strain selection and plant breeding (cooperatively with SCS and BPISAE), and grazing management on seeded areas. Particular emphasis is currently being given to publication of the accumulated results of past work.

CORRELATION OF PROGRAM WITH PROBLEMS

Considering first the special problem areas of the Intermountain region (p. 7), it must be admitted that our present effort does not meet their needs very well.

Ecological work on mountain grasslands is almost at a standstill, and inasmuch as this work has been concentrated on subalpine range and sedimentary formations in central Utah, it needs to be extended to other subalpine situations and lower mountain zones, not only in that State but in Nevada, Idaho, and Wyoming. Work in artificial revegetation in mountain grasslands is somewhat more adequate, but it needs strengthening particularly in Nevada and Wyoming.

The granitic soils of southwestern Idaho and the eastern front of the Sierra are receiving some attention, but not enough, from the standpoint of artificial revegetation. At present no ecological work is being done on granitic soils. This activity could be correlated with an ecological study of cheatgrass in southwestern Idaho if manpower were available. A large number of plots and quadrats, established about 20 years ago and carefully studied for about 10 years, together with several exclosures, are available to get this research off to a good start. The fact that the problems of mountain grasslands, cheatgrass, and granitic soils overlap gives this particular area a high priority in reorientation of our research effort.

Most range research in the Colorado River Basin has been done at high elevations, and very little has been done at low elevations where the problems of sediment control are most acute. Studies to date in the low elevations have been a few species adaptability trials. These low elevations should have high priority for expanded research both in range ecology and artificial revegetation.

The work of all projects contributes to the ecological basis for management (p. 7). However, effort in only one--Summer Range, now largely inactive--is directed particularly toward the specific and urgent problem of ascertaining the character of normal vegetation and normal soil erosion.

All management projects are involved in the problem of determining range condition and trend (p. 8), but of the many vegetal types in the region only a few have received much attention. These include sagebrush-grass in southeastern Idaho, aspen and subalpine grasslands in central Utah, and shadscale-winterfat in western Utah.

All projects are concerned, similarly, with the influence of animals in the range complex (p. 9), but the detailed studies that have been made are few: sheep on sagebrush-grass and on shadscale-winterfat types, and cattle on artificially seeded crested wheatgrass, are being studied in designed and well-controlled experiments with reasonably large groups of animals. Other grazing studies on seeded areas, of cattle in a mountain brush type (now discontinued) and of deer-sheep and deer-cattle relationships are less adequate. Two small studies are also under way on the effects of pocket gophers on subalpine grassland.

Most projects have done some work with problems created by undesirable plants (p. 10). Except for sagebrush, tarweed, and wyethia, little study has been made of undesirable plants, and our progress in control has been slight. We have observed, as with blackbrush burning in southern Nevada, what appear to be misguided efforts at range improvement through burning, but have not been able to do the research needed either to guide burning into constructive channels or to demonstrate its undesirable effects. We have been unable, to date, to make more than a few observational studies of halogeton. The most important problem plant of all--cheatgrass--is receiving virtually no attention, either from us or from anyone else, in the way of ecological research.

The fact has been pointed out that much progress has been made in artificial seeding for the improvement of forage and soil cover (p. 12), and that much remains to be done in this respect. Of all problems this appears to be most adequately taken care of--but this is because the most difficult phases have been split off in the group of problems concerned with seeding harsh sites. The progress that has been made in seeding research to date makes it highly probable that continued studies on the better sites of the adaptability of species and strains, of legumes, of mixtures, and of browse species for game, will yield rich dividends.

A greater challenge for research in artificial revegetation lies in finding adapted species and methods of planting for harsh sites (p. 12). Some studies, mostly of a preliminary nature, have been carried out, and the failures we have had, and the limited successes in some cases, have taught us much. Because the problem of soil erosion is so acute on many of these harsh sites, and because getting plants to grow on them is so difficult, it seems probable that research in artificial revegetation should concentrate on this field in the future.

At present an intensive review of range research problems in the Intermountain region is under way. The foregoing discussion, based upon a review of range management problems in 1949, is a preliminary appraisal, and its soundness will be tested in consultation with the entire range research staff this winter. Reorientation, if that is necessary, will be undertaken in the year ahead.

HIGHLIGHTS OF RANGE RESEARCH IN 1952

Winter Range

The major effort on the winter range project was completion of the manuscript, "Increasing Forage Yields and Sheep Production on Intermountain Winter Ranges." This manuscript gives the results of 13 years' study on various phases of winter range grazing, a brief summary of which follows:

The 65 million acres of winter range within the Intermountain region furnish forage for approximately 4 to 5 million sheep for a period of 4 to 6 months each winter. These ranges occupy the more arid portions of the region and are characterized by sparse vegetation consisting chiefly of low shrubs and grasses.

The Desert Experimental Range was established by the Forest Service in 1933 to study management problems on winter range. Fifty-five thousand acres of representative range in western Millard County, Utah, were fenced into experimental pastures and allotments. The plant types and subtypes characteristic of the winter range were well represented within the experimental area. Although several hundred plants are found on the winter range, only about 25 or 30 are abundant and palatable enough to be classed as important forage species. The most important of these are shadscale, winterfat, bud sagebrush, black sagebrush, galleta, Indian ricegrass, squirreltail, needlegrass, and wheatgrass.

Herbage production as estimated in October was found to be closely associated with precipitation received during the preceding 12 months. Average 12-month precipitation between October 1935 and September 1947 was 6.69 inches at the Desert Experimental Range. Average herbage production was only 219 pounds per acre, with a maximum yield of 468 pounds in October of 1947 following precipitation of 11.10 inches, and minimum yield of 75 pounds per acre in 1943 following two years of severe drought.

The close relation between precipitation and herbage production provides a basis for estimating or predicting the annual forage crop from the precipitation received. Analysis of data from the experimental pastures, where the vegetation is largely shadscale, winterfat, and grass, indicates that precipitation received between October and December is twice as effective, and that for January to March about 1-1/2 times as effective in the production of herbage, as precipitation received between April and September. The equation for estimating herbage yield from precipitation is:

$$Y = 31.44x - 76.18 \pm 21.33$$

where Y is estimated herbage yield and x is precipitation for the previous 12 months (October to September) weighted by multiplying the precipitation for October-December by 2, January-March by 1-1/2, and April-September by 1. With estimates of herbage production made in October, almost one month before the winter grazing season begins, stockmen can adjust their stocking rate or provide supplemental feed to help carry the sheep through winters when forage production is low.

Herbage yields were affected by grazing intensity. In the experimental pastures total herbage show trend increases of 54, 46, and 34 percent for light, moderate, and heavy grazing respectively, over the period 1935 to 1947. The greatest difference in yield occurred in winterfat, the most productive palatable shrub in the pastures. This species increased 239, 321, and 33 percent under light, moderate, and heavy grazing. When winterfat yields are adjusted for variations in production caused by fluctuations in annual precipitation, trends are still markedly upward, although essentially equal for moderate and light grazing, but under heavy grazing the trend is slightly downward.

Russianthistle, a low-value annual that has invaded many overgrazed and deteriorated winter ranges, almost disappeared where range was moderately grazed or protected from grazing. As an example, an area where Russianthistle produced 60 percent of the vegetation was fenced in 1937. Three years later Russianthistle was almost completely replaced within the enclosure by winterfat and Indian ricegrass. By 1947 Russianthistle produced only 2 percent the herbage within the protected area and 54 percent on the adjacent heavily grazed range. At the same time recovery in forage production of desirable perennial species was marked and surprisingly rapid. Such improvement was noted in black sagebrush, bud sagebrush, winterfat, Indian ricegrass, squirreltail, and other desirable winter range species. Range improvement was essentially the same under moderate grazing as under total protection.

Ewes on moderately grazed range maintained body weights 4 to 18 pounds per head greater than those on heavily grazed range. They also produced about a pound more wool per head and 11 percent more lambs, and suffered less death loss. Costs of feeding supplements to sheep in poor condition was also lower. Income from herds wintered at moderate grazing levels under good management averaged $3.46 per head as compared to $1.69 for herds on heavily grazed range.

Spring-Fall Range

Since 1932 a fairly complete record of plant growth, development, and yield has been maintained on native vegetation in ungrazed enclosures at the U. S. Sheep Experiment Station. In addition, daily records of precipitation and temperature have been maintained at the cooperative weather station. Because the weather station is centrally located with respect to the enclosures and is within a mile of the most remote, its records are believed to be closely applicable to the growth of the vegetation under study.

Plant development

Systematic plant-development records are available over a 7-year period, 1941-47, for 7 grasses, 12 forbs, and 4 shrubs. Averages for this period show that development is generally early in forbs, intermediate in grasses, and late in shrubs (Table 1). Although grasses begin growth earlier than forbs, all subsequent stages of development occur first in forbs. Flowering is earlier in forbs than in grasses and much earlier in grasses than in shrubs. Both forbs and grasses complete much of their development during June and begin to dry, but corresponding stages of development in shrubs are not reached until August.

Table 1.--Average development of forbs, grasses, and shrubs at U. S. Sheep Experiment Station, 1941-47. Days after April 1 are given after each date

	Forbs	Grasses	Shrubs
Snow off	April 1: 0	April 1: 0	April 1: 0
Leaf growth starts	April 11:10	April 3: 2	April 16: 15
Twig growth starts	--	--	June 6: 66
Flower buds visible[1/]	April 30:29	May 14: 43	June 12: 72
First bloom[2/]	May 14:43	June 8: 68	July 20:110
Full bloom	May 26:55	June 19: 79	August 3:124
Leaves drying	June 16:76	July 1: 91	August 5:126
Seed ripe	June 18:78	July 9: 99	August 27:148
Seed dissemination over	July 4:94	August 4:125	--

[1/] "Flower stalks appear" for forbs and grasses.
[2/] "Heads fully out" for grasses.

Data for the 16-year period, 1932-47, were used to determine the relationship between plant development and temperature and precipitation. Although plant-development records for these years are available for only 8 species (5 grasses and 3 forbs), it is thought that the 16-year period provides a more reliable correlation than the 7-year period (1941-47) with a greater number of species. In order to obtain an expression of earliness or lateness of development for each year, the species were combined and the average date at which they reached the various stages was computed.

Early stages of plant development are correlated with temperature of the growing season. Average date of the stage "flower stalks appear" for the 8 species and March-April mean temperature produces a significant correlation coefficient ($r = -.619^{*}$), and the correlation of "full bloom" with March-May mean temperature is highly significant ($r = -.927^{**}$). (Hereafter one and two asterisks will indicate statistical significance at the 5 and 1 percent levels respectively.) In nearly every year, plant development earlier than average was associated with mean temperature higher than average; similarly, development later than average was associated with lower than average temperatures.

It was thought that date of snow melt might be strongly related to early plant development, but correlation between "snow off" and "flower stalks appear" is not significant ($r = .429$). This correlation is much weaker than that of the same developmental stage with temperature.

Development during the latter part of the growing season, however, is more closely related to precipitation. Date of "plant drying" is positively correlated with April-May precipitation (r = .812**)--that is, plant drying is delayed in those years having higher than average April-May precipitation. This stage is also negatively correlated with April-May mean temperature, but to a lesser degree (r = -.635*). Date of "seed ripe" is positively correlated with April-May precipitation (r = .718**). Correlation with temperature of the same period is not significant.

Height growth and range readiness

Records of height throughout the growing season are available for two of the most important forage species, bluebunch wheatgrass (Agropyron spicatum) and arrowleaf balsamroot (Balsamorhiza sagittata), for a 16-year period, 1932-47. In addition records of herbage weight at various times throughout the growing season are available for these two species over a 12-year period, 1936-47.

Since earliness or lateness of plant development is strongly influenced by temperature, it seemed logical that height growth would be also. Correlation coefficients were computed between percent of total annual leaf height on May 5 and March-April mean temperature (r = .822**), between height on May 15 and March-May temperature (r = .726**), and between percent of total annual weight on May 20 and April-May mean temperature (r = .640*). It seems obvious, then, that as with reproductive development, increments in height or weight during the growing season are strongly influenced by annual variations in temperature.

Experience has shown that ranges in this locality are ready to graze each spring when bluebunch wheatgrass reaches a height of 2-1/2 inches. Attempts were made, therefore, to relate the date this height is attained to date of snow melt and to temperature. Although it is not closely related to snow melt (r = .437), this date is highly correlated with March-April mean temperature (r = -.909**) and with mean temperature of March (r = -.813**). Since it is important to know date of range readiness a few weeks in advance, March temperature has the more practical value for predicting this date. The regression equation for estimating date of range readiness from temperature is:

$$Y = 65.86 - 1.39x \pm 5.66,$$

in which Y equals number of days after March 31 and x equals March mean temperature in degrees Fahrenheit. Date of range readiness averaged April 25 for the 16 years and varied from March 30 to May 7, a spread of 38 days. The scatter of points around the regression line is such as to indicate that in 2 out of 3 years the actual date of range readiness will fall within about 6 days of the date predicted.

Annual herbage production

Herbage yield (as determined by weight estimates) of grasses, forbs, and shrubs are available for 10 years of the period, 1936-50 (Table 2). During these years, there was considerable fluctuation in herbage production; total of the highest year was almost double that of the lowest. Of the individual classes, grasses had the greatest variation and forbs the least.

Table 2.--Air-dry herbage production in ungrazed enclosures at the U. S. Sheep Experiment Station for 10 years of the period, 1936-50

Year	Grasses	Forbs	Shrubs	Total
		Lbs./acre		
1936	120.18	183.78	238.61	542.57
1937	198.33	179.78	431.25	809.36
1938	297.01	252.50	515.87	1,065.38
1939	234.34	232.24	397.00	863.58
1940	210.31	237.03	468.46	915.80
1941	259.92	295.97	412.90	968.79
1942	175.20	247.89	519.03	942.12
1947	128.51	198.02	385.93	712.46
1949	153.29	194.48	403.72	751.49
1950	194.98	224.37	392.70	812.05

Correlation analysis was again used to show the relation of yield to precipitation and temperature. In order to minimize the possibility of overlooking significant relationships, a large number of correlation coefficients were computed between yield of the different classes of vegetation and precipitation and temperature of the various seasons. Even though many of these were not statistically significant, it is noteworthy that in most cases correlation with precipitation is positive and with temperature, negative.

Correlation coefficients between precipitation of the July to March period immediately preceding the growing season and yield are:

	r
Grasses	.787**
Forbs	.920**
Grasses and forbs	.900**
Shrubs	.531
Total	.810**

Correlations of precipitation during the growing season with herbage yield are not significant except in the case of shrubs (r = .701*). Apparently moisture available in the fall and at the beginning of the growing season has more effect on subsequent yield than that which falls during the period of active growth.

Although none of the correlation coefficients between mean temperature and yield are significant, a number of relationships are apparent. The fact that all correlations between yield and mean temperature during the spring are negative indicates that high temperatures are often associated with low yields. This is also true, though to a lesser extent, for the July to September period preceding the growing season, but for the October to March period a positive correlation is indicated. Generally, then, highest herbage yields are associated with relatively low temperature in July through September preceding the growing season, higher than average temperatures during October through March, and low temperatures during the growing season, April through June.

Since herbage production is best correlated with July-March precipitation and April-May mean temperature, multiple correlation coefficients were computed between yield and these two factors. These are:

	r
Grasses	.799*
Forbs	.921**
Grasses and forbs	.906**
Shrubs	.636
Total	.848*

Comparison with the simple correlation coefficients between yield and precipitation indicates that little was gained by the inclusion of the temperature factor.

Partial correlation coefficients were also computed in these cases to allow examination of precipitation and temperature effects independently. Although elimination of the effects of one factor resulted in slightly lower correlation between yield and the other, in no case was the sign changed. In other words, July-March precipitation is still positively correlated with yield after the effect of temperature is eliminated, and April-May temperature is negatively correlated with yield even after elimination of the precipitation effect.

Utilization Standards

As part of condition and trend studies in the aspen type, and since aspen reproduction is a common indicator, some aspects of aspen reproduction are being investigated. Reproduction has practically ceased along the edges of many aspen stands in central Utah. Here aspen reproduces almost entirely by root shoots, and one would expect the stands to enlarge progressively outward, but at the edges of many of them there is a sharp break from apparently mature trees to a herbaceous or shrubby vegetal type. In some areas there is evidence that grazing by livestock or deer is responsible for absence of aspen reproduction but not always. This sharp break exists, for example, in one exclosure that has been fenced against both deer and livestock for as long as 22 years.

Four aspen stands ending abruptly against other types were selected in Ephraim Canyon for study in 1950. The sites varied in elevation from 9,000 feet at station A, at about the center of the aspen zone, to 8,000 feet at station D at the lower edge of the zone. Station A was fenced against livestock at the beginning of the study; station B had been fenced against livestock in 1914; station C against livestock and deer in 1931; and station D against livestock in 1929. The openings at stations A and B were covered mostly by herbaceous vegetation, and at stations C and D by shrubs.

At each station two comparable plots, 25 by 25 feet, were selected at the edge of the aspen. One plot was cleared of all vegetation and trenched to a depth of 18 to 24 inches on three sides, excepting the side against the aspen stand, to prevent the growth of roots into the plot from plants outside. The other plot was left uncleared and untrenched.

Numbers of shoots in 1951 and 1952 are given in Table 3. In 1951 aspen shoots on the cleared plots were to those on the uncleared plots about as 4 is to 3, and in 1952 about as 5 is to 1. Between 1951 and 1952 total number of shoots on the cleared plots increased 93 percent while those on the uncleared plots decreased 50 percent.

Table 3.--Number of aspen shoots in 1951 and 1952 on cleared and uncleared plots at four study areas

Study area	Cleared plots		Uncleared plots	
	1951	1952	1951	1952
A	2	5	3	0
B	3	18	1	0
C	2	0	0	0
D	21	31	18	11
Total	28	54	22	11

In general differences at the various stations are consistent with the totals, although numbers of shoots varied greatly between stations. Station D produced by far the most shoots. Response at station C, where deer as well as livestock have long been excluded, has been least marked.

In view of the possibility that trenching the cleared plots may have stimulated their greater production of aspen shoots, the shoots within 5 feet of the 3 outer edges of each plot were excluded from consideration. On these smaller areas on the cleared plots there were 16 shoots, and 11 on the uncleared, a ratio of about 3 to 2. In 1952 the totals were 29 and 9 respectively, a ratio of 3 to 1. It is therefore evident that the difference in shoot production is associated with clearing rather than with trenching.

From the evidence so far collected it is inferred that herbaceous and shrubby vegetation tend to prevent aspen reproduction in openings and at edges of the aspen forest. It is presumed that this is because of competition for soil moisture, although there are, of course, other possible explanations.

Artificial Revegetation

How to seed tarweed range

To answer recent questions regarding procedures for successfully seeding ranges infested with cluster tarweed, the following summarization of experimental results is given.

Large subalpine areas and openings are infested with this low-value annual. Easy accessibility and good soil make these ranges potentially some of the best. Natural improvement is generally very slow, principally because of the keen competition from tarweed. Large numbers of pocket gophers and heavy grazing may be contributing factors to slow natural recovery.

Mechanical treatments and seeding trials through 1943 and 1945, and spraying trials on the Manti-LaSal National Forest with 2,4-D in 1949 furnish the fundamental principles for seeding tarweed ranges successfully. Several administrative seedings, particularly on the Wasatch and Manti-LaSal Forests bear out the correctness of the procedures.

The important essential is to eliminate the tarweed completely. This can be done by shallow but complete surface cultivation with a duckfoot weeder or disk as soon as it is possible to work the ground in spring. At this time tarweed has only the first two primary leaves and is readily destroyed with slight disturbance. If land is too rocky for surface cultivation, spraying with 2,4-D at the rate of 1/2 to 1 pound of acid equivalent, either in amine salt or ester base, effectively eliminates tarweed as well as other annuals. Such a rate of application has little or no lasting effect on the commonly associated perennials.

Adapted grasses should be planted immediately to take advantage of the residual moisture in the ground from snow melt, as well as summer storms. If broadcast, seed can be put out ahead of the duckfoot weeder or disk. Experience by the Manti-LaSal Forest shows that cultipacking or rolling improves stands from broadcast planting, especially when done in the spring. Use of packing wheels would no doubt improve stands when drilling. Rocky areas sprayed with 2,4-D are best broadcast and then run over by a pipe harrow to cover the seed.

Soil cultivation after foliage leaves develop, but before seed begins to form, will also kill tarweed. However, complete kills are much more difficult because the ground has often hardened. To eliminate tarweed at this later date it may be necessary to resort to a heavy disk, such as an offset or wheatland. These areas are best planted in late fall, because early residual moisture in the surface soil has largely disappeared and seed germinates poorly.

Spraying tarweed with 2,4-D, after a number of the foliage leaves have developed, kills 90 percent or more of the tarweed plants, but enough small plants, protected by the leaves of larger ones, escape to perpetuate the tarweed.

Seeds of tarweed have the unusual characteristic of completely germinating each year. Consequently, full elimination of plants before seed development eliminates possibility of new plants, except from seeds blown or carried to the treated area. Most other mountain annuals have a high degree of dormancy, and some seeds may lay in the ground several years. Thus, it is the rule to have a profuse stand of knotweed or similar annuals on those areas where tarweed was eliminated but not planted until late fall. While such weeds may depress rate of development of seeded species, successful stands of grass are usually obtained.

Cultivation and planting after tarweed has opportunity to mature seed have been universally ineffective. Even moldboard plowing, intended to cover the seeds so deep they could not emerge, has failed of its purpose because enough tarweed seeds escape to make a stand. To be safe, treatment should be completed before the tarweed flowers.

Even with initially good seedling establishment of forage species, where tarweed is not eliminated, development into fully productive stands is very slow. For example, the first year after planting, in the fall of 1943 and early spring of 1944, green-weight yields from the seeded forage were 6,000 pounds per acre on the spring-treated area and 85 pounds per acre on the fall-treated area. Four years later respective yields were 5,470 and 354 pounds per acre; and 9 years later, in 1952, 8,000 and 2,100 pounds per acre. The fall-treated area still supports a large number of tarweed plants, and it will be several years before its production of grass equals that of the spring-treated area where a good kill of tarweed was made initially.

Because heavy gopher infestation is common on tarweed areas, grasses which are least disturbed by these animals should be the basic part of mixture. Two of the best are tall oatgrass and mountain brome. They not only maintain themselves but are aggressive spreaders. Smooth brome develops slowly, presumably because gophers eat the roots and rhizomes; but it is well to include smooth brome in a mixture for these ranges because as the grass stand develops gopher activity lessens and the brome becomes a valuable and permanent part of the forage. On the basis of adaptability tests the following mixture, totalling 13 pounds per acre, is suggested: mountain brome (native) 4 pounds, smooth brome (northern strain) and tall oatgrass 3 pounds each, and meadow foxtail, timothy, and orchardgrass, 1 pound each.

New species adapted to important range types

Detailed reports of species adapted to various climatic zones in the Intermountain region have appeared in past annual reports. Some grasses showed particular adaptability to important types in 1952, and are worthy of additional comment.

On salt-bearing lands it was found that stiffleaf quackgrass (Agropyron pungens) and mammoth wildrye (Elymus giganteus) have possibilities. In addition to being tolerant to high salt concentration, they remain green throughout the summer on land where saltgrass often becomes dry and unpalatable. While observations have been made only one year, these species give promise of supplementing tall wheatgrass and Russian wildrye, grasses which have shown excellent adaptability on salty ranges.

In mountain brush types and openings in aspen Amur wheatgrass (Agropyron amurense), which resembles intermediate wheatgrass, has demonstrated excellent adaptability. Whether it will prove superior to intermediate wheatgrass remains to be determined.

On subalpine ranges Tomentose (Bromus tomentosus) and meadow foxtail (Alepocurus pratensis) are well suited for general range planting. Both are bunchgrasses which are aggressive natural spreaders from seed. Tomentose brome is similar to native mountain brome, but retains succulence better in late season and is much longer lived. Because of its light, fluffy seed, meadow foxtail shows particular ability to establish new plants at a distance from the parent plant. This grass shows exceptional usefulness for broadcasting on moist to actually wet areas in all climatic zones.

Experimental plantings on very dry sites

Relative ratings of seedling stands on four dry sites in the Colorado River drainage were presented in the 1951 annual report. Of the species listed, crested wheatgrass, Russian wildrye, and squirreltail showed best survival through the first year. These species also showed some additional emergence in the second growing season. Other species which came up in 1952 were Indian ricegrass, giant wildrye, and Nuttall's saltbush, few plants of which came up the first year. Their ultimate survival remains to be seen.

Although these results are preliminary, they follow trends of older plantings on dry sites in the Great Basin. On a dry shadscale site near Gunnison, Utah, crested wheatgrass, Russian wildrye, squirreltail, Indian ricegrass, and bulbous bluegrass have shown best survival from 60 selected species planted on the area twice or more since 1947. Other species such as bluebunch, intermediate, stiffhair, tall, and Amur wheatgrasses have shown good initial establishment but, except for a few individual plants, have died later.

On dry sites in both the Colorado River and Great Basin drainages, it has been impossible to obtain good initial stands of species native to the Southwest and southern Great Plains. In instances when a few seedlings have resulted, they have generally failed to survive for any extended period. Good initial establishment of a number of these species has been obtained in the mountain brush zone, but nearly all have failed to survive more than the first 2 years.

Grass-legume mixtures on a mountain brush site

In 2-year-old plantings of nine legumes seeded individually with each of four grasses in the mountain brush zone, the grasses, which become established more quickly, had better stands and much higher yield than the legumes. The grasses in order of highest average yield were intermediate wheatgrass, crested wheatgrass, smooth brome, and mountain brome, with production ranging from 4,417 to 2,562 pounds per acre, green weight. Highest yielding legumes were chickpea milkvetch, Ranger alfalfa x Medicago glutinosa, Ladak alfalfa, Rhizoma alfalfa, and sicklepod milkvetch, with yields ranging from 375 to 175 pounds per acre. Yields of sickle alfalfa, deerfoot trefoil, bramble vetch, and flat peavine were somewhat lower, ranging from 56 to 14 pounds per acre. The legumes yielded 2½ to 3 times higher when planted with the two brome species than when planted with the two wheatgrasses. Supplementary 2-year-old plantings of three legumes with smooth brome showed the yield of chickpea milkvetch to be about twice that of sicklepod milkvetch and 1-1/2 times that of Ladak alfalfa.

A 5-year-old broadcast planting of Ladak alfalfa with a mixture of grasses in the mountain brush zone yielded considerably more than plantings of grasses broadcast singly at the same time. The alfalfa-grass mixture yielded 8,000 pounds per acre, green weight, with alfalfa constituting about two-thirds of the yield and grasses one-third. By comparison, pure seedings of intermediate wheatgrass, tall wheatgrass, and smooth brome yielded 5,300, 3,600, and 2,800 pounds per acre, respectively.

Strain testing

Finding new and better strains of adapted species is becoming increasingly important. This work is being carried on in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering, the Soil Conservation Service, and the state experiment stations. To discover the best strains, and be sure of their superiority for range lands, performance must be observed over a period of several years. Promising strains are annually being entered into comparative plantings. Reports of performance are sent cooperators and other interested parties as soon as results warrant release.

In general native grasses such as mountain brome, slender and bluebunch wheatgrasses, Indian ricegrass, and squirreltail vary greatly in performance under different conditions. After 10 years, a source of mountain brome, originally from a collection in Colorado known as 78, shows superiority over all other strains of this grass in high mountain plantings. A local collection of slender wheatgrass known as 38, shows similar superiority over other sources of this grass in mountain brush and aspen types.

Of the two general types of crested wheatgrass, Fairway demonstrates definite superiority over standard on mountainous ranges. On a long-time basis it is more persistent and equally productive, although standard types are sometimes the more productive at the outset. Under grazing Fairway is taken more uniformly, and it generally makes a better ground cover.

Comparisons of a large number of smooth brome strains show general superiority of southern to northern strains on lowland and mountain brush ranges. Within the aspen-fir zone the two types are about equally productive, but in the subalpine zone the northern strains produce more. The southern strains, however, make a better sod and are more aggressive spreaders. For this reason southern strains probably should be used on high watersheds, at least in mixture with northern strains. Achenbach, Lincoln, and Fisher are common southern strains; Manchar, Martin, and Canadian are common northern strains; and all are commercially available.

It is immensely important to find legumes that are adapted to range revegetation. Of the many native and exotic legumes that have been tried, some of the alfalfas, more particularly those which spread from the crown (creepers), have shown great promise. Performance trials of nine strains of alfalfa, selected by the Bureau of Plant Industry for having possibilities on grazing lands, have been under way for 2 years in the mountain brush and subalpine zones in Ephraim Canyon. On a good site in the mountain brush zone the following strains, in order of yield, were best in 1952: Sickle (or yellow-flowered) alfalfa (SCS P-550), Rhizoma, Pilca Butta, Nomad, and Grimm. On a fair but drier site in this zone the order was: Sickle alfalfa (SCS P-550), Buffalo, Ranger, Sevelra, and Grimm. In the subalpine zone, Ranger, Sickle (SCS P-550), Ladak, and Sevelra showed the best yields. Of these strains, Rhizoma, Nomad, and Sevelra are commercially available "creepers." On the basis of showings made here, they appear to be comparable in production to the taproot types and in addition are less subject to damage by burrowing rodents that cut the taproots of standard strains.

Persistence of seeded grasses

In 1952, information was obtained on the persistence of 25 grasses that had been seeded with smooth brome following burning on a mountain brush type in central Utah in 1944. Prior to burning this area had been dominated by big sagebrush and mountain snowberry. Each species was broadcast on separate contour strips 400 feet long and 6 feet wide at approximately 14 pounds per acre. Smooth brome was then broadcast over the area at the rate of 5 pounds per acre to provide a standard of comparison for the aggressiveness of each grass. Seed was covered by light disking along the contour strips.

Initial stands were good to excellent for all grasses except beardless bluebunch wheatgrass, bearded bluebunch wheatgrass, western wheatgrass, Canada wildrye, and reed canarygrass, all of which showed medium to poor stands. Smooth brome was initially present on all plots but was more suppressed on plots where good stands of the associated species were obtained.

In 1946 two transects, each 3 feet wide, were established at right angles to the strips and data taken on yields of each grass and the associated smooth brome. In 1945 grazing was moderate, in 1946, heavy. In 1947 one transect was fenced to exclude grazing and the other left open to use by cattle and, in some years, sheep. Grazing has been heavy on the unprotected transect until 1952, when it, too, was fenced to provide data on persistence of the grasses after prolonged heavy use.

On the grazed transect the following species were dominating smooth brome:

intermediate wheatgrass
quackgrass
pubescent wheatgrass
meadow brome
spike wheatgrass
creeping wildrye

Here tall wheatgrass was equal to brome. All except meadow brome and tall wheatgrass are rhizomatous. On the protected transect the four species in the left-hand column likewise dominated the smooth brome, as did beardless bluebunch wheatgrass. Here big bluegrass equaled smooth brome in yield. The persistence of intermediate and pubescent wheatgrass under heavy grazing, together with their high yields and relative ease of establishment, show their great value in the mountain brush zone.

Bunchgrasses that gave good stands far outyielding smooth brome at the outset, but that have since been completely dominated by it on both transects are:

mountain rye
mountain brome
awned wheatgrass
slender wheatgrass
tall oatgrass
blue wildrye
Canada wildrye

Crested wheatgrass (standard strain) has not been replaced to the extent of these species, but is gradually giving way to brome.

That heavy grazing has been damaging to the seeded grasses was demonstrated in 1952 in that over-all yield on the heavily grazed transect was only 62 percent of that on the protected transect, although at the outset their yields had been similar. The increased yield of big sagebrush on the heavily grazed transect is likewise indicative of reduced grass vigor. Since 1947 brush yields have increased from 245 to 1,148 pounds per acre, green weight, on the heavily grazed transect, and from 370 to only 573 pounds per acre on the protected transect. Mortality of brush plants, which came in and developed along with the grass, has been greater on the protected transect. Since 1947 the numbers of plants have been reduced from 5.7 to 3.8 per 10 square feet on the protected transect and from 5.0 to 3.9 per 10 square feet on the grazed. In addition, in 1952 there were 1.3 new brush seedlings per 10 square feet on the grazed transect and none on the protected.

Halogeton control

In the upper Raft River Valley on a loam soil in the sagebrush type several grasses were planted in 1949 to determine their ability to suppress halogeton. The stands that resulted from this seeding are rather spotty, presumably as a result of improper seedbed preparation. In parts of the plots where the stands are good the following species very nearly prevented the establishment of halogeton in 1952: crested, bluebunch, intermediate, pubescent, and Siberian wheatgrasses and Russian wildrye. Halogeton is also being suppressed where the 3-year-old sagebrush seedlings scattered on these plots are concentrated with a density of one or more plants per square foot.

Methods of planting bitterbrush

As stated in last year's report, weeds may be eliminated from an area for a full growing season if the surface few inches of soil wherein are harbored the potential weeds (in the form of seeds), are scraped off the previous fall. On an area near the South Fork of the Boise River several small plots were scalped at different dates and different depths late in 1951 and then seeded to bitterbrush. The original annual cover there was composed mainly of cheatgrass (Bromus tectorum), but contained noticeable amounts of filaree (Erodium cicutarium) and a very few Amsinckia, annual sunflower (Helianthus annuus) and Gayophytum diffusum. The number of weeds growing on some of these plots in 1952 is shown in the tabulation below. Each figure is an average of 20 plots and represents the number of weeds per square foot.

Treatment, 1951	Weed numbers, spring 1952
Scalped down to 3 inches, August 28	2.5
Scalped down to 3 inches, November 1	0.6
Scalped down to 1 inch, November 1	0.9
Not scalped	143.2

These figures show that 1-inch scalping is deep enough for weed removal on this site, where trampling by game and livestock has been very light for the past several years. On range where the soil is quite loose and where animal use has been heavy more weeds would probably emerge from a plot scalped only to 1 inch than there were here. Late August was not too early for scalping to reduce the weeds to a negligible few, but again, these results probably would not apply on an area where the annuals are mainly species like Polygonum douglasii and Gayophytum diffusum, that shed their seed in late summer.

Bitterbrush planted in these plots suffered extremely high mortality from two causes in spring and early summer: drought and insects. Drought killed seedlings only on plots where weeds had not been removed. There the mortality was almost complete by mid-June. Planting methods had no bearing on the insects' choice of plants to feed upon. The damage done in the earlier part of the season was by larvae which ate the cotyledons and very small leaves, but the loss of seedlings was very light. The later destruction, which was total, was the result of a very heavy concentration of grasshoppers that infested the area and turned on the bitterbrush after the herbaceous vegetation dried up. It seems that some of the seedlings might possibly have survived despite their having been stripped of most of their leaves if the season had not been unusually dry in the later half of 1952. Those that were clipped off below the cotyledonary node were certainly killed by the grasshoppers.

Herbaceous species for game winter range planting

By early spring, at or shortly after general snow melt, deer develop a preference for green succulent forage. On the South Fork of the Payette range the earliest vegetation to attain a grazable height above the litter of the previous year's cover are the widely scattered leaves of wild onion (Allium spp.) and wild hyacinth (Brodiaea douglasii), and the deer cover a lot of territory for a few bites of these green leaves, seeming to have no taste for the browse twigs made available by melting of the snow.

Some introduced perennial grasses are almost as early in resumption of growth in spring as these natives, and they are certainly more productive. The earliest of several grasses being observed in this area are bulbous barley (Hordeum bulbosum) and mountain rye (Secale montanum). Nearly as early, and with seed more readily obtainable at present, are intermediate wheatgrass (Agropyron intermedium) pubescent wheatgrass (A. trichophorum), and crested wheatgrass (A. cristatum). Crested wheatgrass is known to be adapted to this range; the others are showing promise.

Cattle grazing at Benmore

The grazing experiment on crested wheatgrass at Benmore has been outlined in considerable detail in previous annual reports. An article summarizing the main findings up to 1952, entitled "Cattle Gains and Vegetal Changes in Relation to Grazing Treatments on Crested Wheatgrass" is scheduled for early 1953 publication in the JOURNAL OF RANGE MANAGEMENT.

Briefly, the Benmore experiment involves all combinations of 4 methods and 3 intensities of grazing, replicated twice, on 24 100-acre pastures of crested wheatgrass. Pastures are grazed by cattle for approximately 60 days in spring and, when regrowth is adequate, again in fall.

Daily cattle gains presented in previous annual reports were not corrected for weight losses of cows that calved in the pastures. These corrected average daily gains under the different grazing treatments for the spring periods 1948 to 1951 are shown in Table 4. Although cattle gains in 1952 have not been fully analyzed, indications are that they follow these general trends. Animals gained considerably less on heavily grazed pastures than on moderately and lightly grazed pastures. This is also reflected in lowered calf gains under heavy grazing. Cattle averaged least rapid gains under rotation grazing and most rapid gains when removed 10 days early toward the end of the season. These different methods of grazing had little effect on daily calf gains.

Table 4.--Average daily gains made by adult cattle on crested wheatgrass grazed at three intensities and under four methods during the spring seasons of 1948 to 1951

Method of grazing	Intensity of grazing			
	Light	Moderate	Heavy	Average
	Pounds	Pounds	Pounds	Pounds
Rotation	2.80	2.76	2.02	2.53
Continuous	3.07	2.86	2.17	2.70
10-day deferred	2.97	2.82	2.24	2.68
10-day short	3.28	3.18	2.40	2.95
Average	3.03	2.90	2.21	2.71

Average utilizations in 1952 were 51.8 percent, 63.4 percent, and 80.5 percent for lightly, moderately, and heavily grazed pastures compared to planned intensities of 50, 65, and 80 percent, respectively. In 1952, average stubble heights for the three intensities of use were 4.6, 3.4, and 1.9 inches. Average dry-weight yields of crested wheatgrass, calculated from the amount of herbage left and the percent utilization, were 795, 815, and 736 pounds per acre for the respective intensities of use. These are slightly higher than the 1951 yields of 638, 644, and 623 pounds per acre.

Rubber rabbitbrush and big sagebrush continue to increase in the Benmore pastures. Rabbitbrush has increased 140 percent in yield on plots where it was present in 1948. This results mainly from an increase in size of plants, but also from an increase in number. The number of plants over 4 inches in height has increased 21 percent, and under 4 inches, 347 percent on these plots. In addition rabbitbrush is now present on 26 percent of the permanent plots whereas it was present on only 14 percent of the plots in 1948.

Yield of sagebrush has increased 246 percent on plots where it was present in 1948. Number of plants over 4 inches high has increased 30 percent, and under 4 inches, 198 percent. Sagebrush is now found on 10 percent of the permanent plots, whereas in 1948 it was found on only 6 percent.

Some pastures contain considerably more brush than others, but these pastures tended to have most brush at the outset of the experiment. Thus far there appears to be little relationship between brush invasion and pasture-wide grazing treatment. Greatest invasion has occurred in patches where stands of crested wheatgrass were poor, but there has been limited invasion by young brush plants into supposedly full stands of crested wheatgrass--principally where grazing has been very heavy.

PROGRAM FOR 1953

Winter range

(1) Complete manuscript on deer utilization of oakbrush range. (2) Summarize plant-growth data on winter range forage species. (3) Continue grazing treatments of pastures and allotments at the Desert Experimental Range, and, if manpower is available, reinventory pastures, allotments, and exclosures in October.

Spring-fall range

(1) Complete analyses of vegetation and sheep-weight data from pasture studies and prepare a report. (2) Revise Farmers' Bulletin 1948, "Sagebrush Burning--Good and Bad." (3) Complete analysis of vegetal and climatic records and prepare a report. (4) On the basis of (1) and (3) begin preparation of a revised work program. (5) Continue

grazing treatments of pastures; inventory plots in Paddocks 1 and 2 and climatic plots in exclosures. (6) In cooperation with Targhee National Forest plan and initiate an administrative study for determining effects of grazing on areas sprayed with 2,4-D to control wyethia.

Utilization standards

(1) Complete report on indicators for judging condition and trend in the aspen type. (2) Continue site-potential study in aspen openings and under canopy, and prepare report on results to date.

Summer range

(1) Complete manuscript, "Subalpine Vegetation of the Wasatch Plateau, Utah." (2) Participate in condition and trend field training conference with Administration.

Big game-livestock range relationships

(1) Complete report on deer-cattle food-habit study. (2) Continue cooperative study of pocket gophers on seeded range. (3) Continue studies on condition and trend on big game-livestock range, with emphasis on the mountain brush type. (4) Continue studies on proper use of game forage species.

Artificial revegetation

Utah and Wyoming.--(1) Complete manuscripts on sagebrush control, seeding Intermountain range lands, response of seeded species to grazing in the mountain brush zone, how to seed range infested with tarweed, and grazing crested wheatgrass with cattle. (2) Complete analysis and appraisal of crested wheatgrass site factor study. (3) Continue species adaptability observations and summarize data from four climatic zones. (4) In cooperation with agencies and individuals extend adapted species and strains to pilot plantings. (5) Continue observations on effectiveness of methods of removing brush competition. (6) Continue observations on grazing crested wheatgrass by cattle and by sheep, supplementing studies on experimental pastures by more extensive observations. (7) Continue observations on the response of a variety of seeded species to grazing. (8) Assess stand establishment of large 1952 seeding in subalpine zone at head of Manti Canyon.

Idaho.--(1) Prepare reports on seeding bitterbrush for game forage and continue field observations. (2) Continue tests and observations on species adaptability on various sites. (3) Test methods of planting grasses, forbs, and browse in cheatgrass and other annuals in the granitic foothills of southwestern Idaho. (4) Continue study on methods of eradicating Medusa-headed wildrye and establishing perennials in its place. (5) Continue study of fertilizers on seeded mountain meadows.

Nevada.--(1) Determine the principal wildland management problems and outline a comprehensive problem analysis for western and northern Nevada. (2) Summarize existing knowledge from revegetation studies in Nevada as a basis for a possible publication and for continuing research. (3) Give particular attention to methods and species for seeding desert shrub and granitic foothill types and for big-game forage.

WATERSHED PROTECTION AND MANAGEMENT

This division is responsible for finding ways and means of improving the usefulness of water yields from the forest and range lands of the region through proper use of land management measures. Progress was made toward this goal during the past year along several lines. Record-breaking precipitation provided firmer guides for evaluating watershed behavior. Several reports were published on past work. Many stream flow records were brought up to date and analyses initiated. A new phase of treatment was begun on the long term Area B experimental watershed. Through a reappraisal of the region's watershed problems, research was extended to include a study of logging disturbance on ponderosa pine lands in Idaho. The following sections present highlight summaries of the present watershed situation, the research program, some of the current findings, and plans for the coming year.

INTERMOUNTAIN WATERSHED PROBLEMS

The Intermountain region is an area of many extensive valleys each of which is flanked by high-elevation mountains and plateaus. Most of the lowland valleys and foothills receive too little precipitation to yield perennial stream flow because virtually all of the rain and snow that falls on them is extracted from the soil mantle by evapo-transpiration processes. The more elevated mountain lands, however, annually receive more precipitation than can be stored in and extracted from the soil and the surplus is drained away to produce stream flow.

The water-yielding mountainous lands occupy less than one-fifth of the regional area whereas four-fifths of the area functions mainly as a vast evaporation pan. Thus, although the region as a whole receives about 220 million acre feet of water from rain and snow in the average year, 191 million acre feet of this supply is dissipated on the land and only 31 million acre feet becomes available as stream flow (Table 1).

Table 1.--Some approximate average annual hydrologic characteristics of Intermountain watershed lands

Land types	Area	Precipitation		Water losses		Stream flow	
	(MM acres)	(In.)	(MMA.F.)	(In.)	(MMA.F.)	(In.)	(MMA.F.)
Forest & subalpine	23	33	63	18	34	15	29
Mountain brush	9	21	16	18	14	3	2
Woodland-sagebrush	86	14	101	14	101	T	T
Desert shrub	46	7	27	7	27	0	0
Crop and other	15	12	15	12	15	0	0
Totals	179		222		191		31

The stream flow from the mountain lands is derived mainly from the melting of snow that accumulates on their slopes during the winter months. Snow melt during the spring and early summer usually proceeds at a rate that is slow enough to permit the released water to sink into the mantle and to percolate slowly to springs and stream channels mainly as seepage flow. There is very little overland flow of water to channels during this period. The percolated seepage flow produces a generally gradual rise in stream flow up to a moderately high discharge in early summer after which the streams fall to progressively lower stages in the late summer, fall, and winter.

There is considerable variation in the time and height of the maximum discharges of seepage flow and in the annual and seasonal volumes of runoff between watersheds in a given year and in the same watershed from year to year. In some areas, such as occurred in most of the mountains of Utah during the spring of 1952, snow melt discharges may reach flood proportions. Generally, however, the regimen of stream flow is such that runoff is locally abundant in the spring when there is a low demand for water but is woefully deficient in the late summer and fall months when irrigation, industrial, and domestic water requirements are the greatest. Most of the high-elevation watersheds yield water yearlong. Many of the watersheds that drain the lower slopes of the mountains yield seepage flow only in the spring or through part of the summer.

Seepage flow from the melting of snow in the mountains is only one aspect of the hydrology of the watershed lands in this region. Torrential summer rains are also a common event. These rains are usually localized over a few square miles in each storm. The depth of rain per storm rarely exceeds 1.0 or 1.5 inches but rainfall rates frequently range up to 3.00 and sometimes as high as 7.00 and 8.50 inches per hour for brief periods. When these rains fall on land having low infiltration capacity that portion of the water that doesn't sink into the ground becomes available for overland flow.

Overland flow is a highly unsatisfactory and potentially dangerous type of runoff. It robs the soil of moisture and thus inhibits the growth of timber and forage. It usually erodes the soil and thereby further decreases the productivity of the land. It can produce floods of great destructiveness downstream, though the volume of the storm flow may be less than 1 percent of the annual runoff from the watershed. The floodwaters are usually so loaded with sediment and debris as to make them practically useless for most purposes by direct diversion. Of greater concern is the fact that the sediments carried in these floods eventually come to rest in main stem rivers to decrease their flood capacity or in reservoirs where they displace valuable water storage capacity.

The phenomenon of overland flow and its attending accelerated erosion is not restricted to the humid mountain lands. It can and does occur also on the more extensive foothill and valley lands. Thus all of the lands draining into the Snake River tributary of the Columbia River and into the tributaries of the Colorado River are a potential source of destructive storm runoff and damaging sediment to downstream developments. Similarly, within the Great Basin area nearly all water storage and conveyance facilities as well as most of the communities, factories, railroads, highways, and farms are situated at low elevations below extensive areas of sloping watershed lands where they too are vulnerable to floods and sedimentation damage.

There is no longer room to doubt that mismanagement of the watershed lands has contributed to the water problems of the region. It is well known that overgrazing, fire, careless logging, and inadequately designed roads and other structural developments have depleted the natural vegetation on extensive areas and that these changes have resulted in accelerated erosion and increased storm flows. Demands for still more intensive utilization of the timber, forage, wildlife, and recreational resources of the wild lands are increasing, posing the danger of further watershed abuse and still more floods and accelerated erosion. There have been some indications that watershed deterioration, especially where it has progressed to the stage of extensive gullying and deep channel scouring, has also resulted in quickened discharges of seepage flow.

The hydrologic characteristics of the watershed lands and the demands for use of the timber, forage, and other resources on them poses three major groups of watershed management problems. These in summary form are as follows:

1. Control of storm runoff and erosion, including:
    a. Determining normal limits of runoff and erosion.
    b. Methods of restoring watershed conditions on deteriorated lands.
    c. Methods of maintaining satisfactory watershed conditions under the impact of grazing, timber cutting, and other land uses.
    d. Development of channel stabilization measures.
2. Increasing water yields without stepping up floods and erosion.
    a. Reduction of evapo-transpiration losses.
    b. Retardation of snow melt.
3. Maintaining water quality.
    a. Against contamination and pollution.
    b. Against impairment of wildlife habitat.

THE RESEARCH PROGRAM

The present research program includes studies on all phases of the storm runoff and erosion control problem except the subproblem of channel stabilization. It also includes some water conservation studies aimed at improving the yield of useful runoff. No research is being done on the problem of water quality.

The going studies fall in the following technical work project categories:

Soil Relations, including studies of infiltration, storage and soil stability.

Plant Relations, including studies of interception and evapotranspiration losses.

Water Relations, including studies of precipitation characteristics and stream flow behavior.

Some phase of each of these work projects is being studied at each of three locations in the region. These locations are (1) the Great Basin Station in central Utah where problems of runoff control and water shortages are especially acute on the subalpine herbaceous range; (2) the Wasatch Research Center in northern Utah where summer storm floods from steep, mixed forest- and brush-covered mountains present a serious problem; and (3) the Boise Research Center in southwestern Idaho, where a loose granitic soil presents a difficult soil stability problem on steep foothill grassland range and steep ponderosa pine forest lands.

The current study areas are all located on lands that yield perennial stream flow as well as storm runoff. Thus many of the principles developed from research at these locations are applicable to other types of humid lands and to more arid lands. There is need, however, to intensify the research at each of the currently established study areas. There is also need for extending research into other areas, especially into the semidesert lands of the Colorado River drainage basin where a serious erosion control problem exists and into the depleted forest lands on the east slope of the Sierra Nevada where there are serious problems of winter snow melt floods and acute shortages of usable water yields.

SOME RESEARCH ACCOMPLISHMENTS IN 1952

At the divisional level a comprehensive research program was formulated for the Intermountain portion of the Columbia River drainage basin. The proposals recommended included a series of both plot and entire watershed studies on (1) grassland spring-fall range, (2) ponderosa pine forest land, (3) mixed forest and range lands, (4) high elevation, humid forest land, and (5) sagebrush winter range land, in the order of priority as listed.

Great Basin Research Center

Efforts at this center were concentrated on completing analyses of supplemental data concerning a study of the behavior of two subalpine, herbaceous range watersheds that has been in progress for 37 years, and the development of a comprehensive outline for publishing the findings from those two areas. Other efforts included the seeding of one of the two subalpine watersheds as a new phase of the long-term study of that area, completion of field work on an exploratory study of the effect of several herbaceous species on water losses, the establishment of plots for a future study of the effects of seeding and grazing on storm runoff, and current maintenance of a network of stream flow and climatic stations.

Plant cover effects on storm runoff and erosion.--During the 37-year period 1915-52, the A and B subalpine range watersheds were subjected to different grazing treatments in successive periods of years. Protection from grazing on Area A during all but the first few years when the plant cover was in a depleted condition, resulted in a slow increase in the amount of herbaceous cover. Successive periods of moderate grazing, very heavy grazing, no grazing, and very heavy grazing on Area B caused fluctuations in the amount of plant cover. At the start of this experiment Area A was in a more depleted condition than Area B and produced about four times more summer storm runoff and sediment than Area B. A thickening of the plant cover on Area A and a reduction in the cover on Area B in recent years has completely reversed the runoff and erosion relationships. Area B in recent years has been producing nearly five times more runoff and eleven times more sediment than Area A (Table 2).

Table 2.--Periodic average annual plant cover conditions, grazing use, and storm runoff behavior of A and B experimental watersheds

Periods	Plant cover		Grazing use		Relative runoff		Relative erosion	
	A	B	A	B	A	B	A	B
1915-23	20	40	Lt.	Med.	4.2	1.0	3.8	1.0
1924-34	40	35	0	Med.	3.1	1.0	1.7	1.0
1935-40	44	27	0	Hvy.	1.0	1.6	1.0	1.6
1941-45	45	38	0	0	2.2	1.0	1.0	1.6
1946-52	50	20	0	Hvy.	1.0	4.8	1.0	11.3

The effect of plant cover on the runoff and erosion produced by these two watersheds is clearly evident when the trends in their behavior over the years are considered. Analysis of the A and B watershed records showed that amounts of storm runoff and erosion can be predicted within reasonable limits of accuracy from amounts of rainfall in a given storm, amounts of rain prior to the storm, and the rate of rainfall during the storm. A comparison of actual with predicted amounts of runoff and erosion, storm by storm, revealed significant trends in the behavior of the two areas over the years. In the early years of the study, Area A tended to produce substantially more runoff and sediment than could be expected by reason of rainfall conditions alone whereas Area B produced less than expected. In recent years the reverse has been true. That is, for given storm conditions, Area A now produces less runoff and erosion than expected whereas Area B produces more.

The tendency for Area B to produce more runoff and erosion than Area A now that Area B is in a more depleted condition than Area A was clearly demonstrated on July 28, 1952 when the two watersheds were subjected to the most intense rainfall in 37 years of record. The volume of rain totalled 1.22 inches and the maximum rate for 5 minutes was 3.12 inches per hour. During this storm, Area A produced about one-third as much runoff and less than one-fourth as much sediment as could be expected from such a rain. Area B produced about 2-1/2 times more runoff and about 40 percent more sediment than expected. Moreover, Area B actually yielded about 5-1/2 times more runoff and 9 times more sediment than Area A (Table 3).

Table 3.--Actual and estimated runoff and sediment production from Areas A and B during the storm of July 28, 1952

	Area A		Area B	
	Actual	Predicted	Actual	Predicted
Runoff (Cu.ft./a.)	206	662	1,139	481
Sediment (Cu.ft./a.)	9	40	81	62

Summer storm occurrence.--An analysis of the 980 storms of record taken on the two Area A and B subalpine watersheds over the period 1915-52 showed that about 70 percent of the summer rains occur within a 6-week period, July 16 to August 31. This also is the period during which rains have been most effective in causing storm runoff and erosion (Table 4).

Table 4.--Periodic occurrence of all summer rains and those that caused runoff, Areas A and B, 1915-51

Periods	Number of all rains		Number of effective rains	
	Total	Average yearly	Area A	Area B
July 1-15	165	4 5	43	24
July 16-31	247	6.7	49	33
Aug. 1-15	227	6.1	48	44
Aug. 16-31	186	5.0	32	32
Sept. 1-15	155	4.2	12	7
Total	980	26.5	184	140

More of the summer storms were effective in producing runoff from Area A than Area B. Two factors were responsible for this difference. For one, Area A has a more distinct central channel than Area B thus making it naturally more conducive to storm runoff. For another, the plant cover on Area A was also in a more depleted condition for a longer period of years than Area B. Notwithstanding these initial differences, after the plant cover on Area B was depleted by overgrazing in recent years, and the cover on Area A was permitted to thicken by protection from grazing, more storms are now effective in producing runoff on Area B than on Area A.

The tendency of storm flow-producing rains to occur most frequently in midsummer makes that portion of the summer grazing season an especially hazardous one on the subalpine ranges of central Utah. Because grazing is known to reduce the density of the forage cover and the infiltration capacity of the soil, grazing disturbance prior to or during the midsummer season should be carried out with great care. On critical areas it may be necessary to avoid any grazing disturbance until late in the summer when there is less chance for the occurrence of a potentially dangerous storm.

New Area A and B study phase started.--The Area A and B watershed study to date has furnished conclusive proof about two aspects of the subalpine herbaceous range watershed lands. One is that depletion of this type of plant cover can step up erosion rates and the frequency and magnitude of storm flow runoff. Another is that rehabilitation of depleted and seriously eroded subalpine range by natural revegetation is a very slow process, even under complete protection from grazing.

Artificial reseeding has long been recognized as a means of restoring plant cover quickly, but the effects of reseeding subalpine range have not been tested on a watershed basis. To determine these effects, Area B was plowed and seeded to a mixture of previously tested grasses in the fall of 1952. Some contour trenches were also installed in order to break up the gully system that had developed in the area. The area will be protected from grazing for several years. The runoff and erosion behavior of the area will be compared with its previous behavior as well as with the behavior of Area A which will be left untreated.

Consumptive water losses.--Many tests have shown that some minimum amount of plant and litter cover is necessary to prevent excessive storm runoff and accelerated erosion. It is also known that the protective plant cover extracts water from the soil in its growth processes and thus creates water storage capacity in the mantle that must be satisfied before water can drain away by seepage to springs and streams. This poses the problem of finding plant species that will not only control storm runoff, keep the soil stable, and provide forage but will also dissipate the least amount of water.

Last fall soil moisture determinations were made on a series of subalpine range sites covered by pure stands of smooth bromegrass, timothy, and bluegrass and by a mixture of annual and perennial weeds. Additional laboratory tests of the soil samples are needed to determine whether the amount of water extracted from the soil by the several kinds of plant cover differed significantly. This study when completed may indicate the possibility of achieving both water conservation and storm runoff control on subalpine range by encouraging the growth of selective species.

Wasatch Research Center

A major effort was made at this center during the past year to bring up to date a large accumulation of stream flow records so that analyses can be made of the runoff behavior of the several steeply sloping, forest-, brush-, and herb-covered watersheds within the Davis County Experimental Watershed. Calculation of discharges was completed for seven of the watersheds, leaving several years of records to be calculated on eight other subbasins. In addition, the findings from a previously reported study on the ground cover requirements for summer storm runoff control on mixed aspen and herbaceous watershed lands was published during the year, and sites were selected and treated for a water conservation study.

Snow melt vs. summer storm flow discharges.--Every year the streams that drain the mountain lands of this region become swollen and remain in moderately high stage for weeks at a time by water that is released from the melting of snow. In most years, these prolonged spring discharges cause relatively little damage. In the spring of 1952, however, virtually all of the streams in north- and south-central Utah reached or exceeded previous records of discharge because of an unusually deep accumulation of snow on the watershed lands. Extensive areas of low-elevation foothill lands yielded water by seepage flow for the first time in many years to augment the flow from more elevated lands. The resulting floodwaters ripped out railroad tracks, bridges, and sections of highways in many places. Much farm land was inundated as were parts of many cities and small communities. The statewide damage caused by the floods has been estimated by the U. S. Corps of Engineers to have totalled about $7,500,000.

The annual snow melt, with its occasional flood menace, is only one aspect of the flood problem in the Intermountain region. Localized summer storms accompanied by torrential rains for brief periods also present a serious flood control problem. The importance of controlling relatively small amounts of summer rainfall on the land where it falls has been dramatically demonstrated in the occurrence of spectacular and destructive mud-rock floods from small steep watersheds in virtually all parts of the Intermountain region. Many, however, still do not appreciate the potential danger of localized, summer storms on high-elevation, steep watershed lands as compared to the flood peaks to be expected from those lands as a result of melting snow.

The behavior of Halfway Creek, a tributary of Farmington Creek in the Davis County Experimental Watershed presents a classic example of the difference in the magnitude of snow melt and summer storm discharges. The water content of the snow pack in this 464-acre tributary watershed during the past winter averaged about 44 inches in depth. This was the greatest snow pack in 17 years of record. The maximum discharge of the stream during the 1952 snow melt season was 20 cubic feet per second per square mile of drainage area. This peak flow reached a height of 2.36 feet as it passed through a 1.0-foot wide weir. The maximum peak was reached after a gradual rise of stream flow over a period of about a month. It took another month and a half for the flow to recede to a low stage. During this period, the stream became slightly turbid, but carried no great quantity of coarse sediment.

On August 10, 1947 this watershed was subjected to a rain of 0.8 inch in volume. For a 5-minute period during this storm, rainfall attained a rate of 5.00 inches per hour. This rain produced overland flow from portions of the watershed where the plant cover was in a depleted condition. This storm runoff developed into a mud-rock flood. It was impossible to measure the discharge of water in this flood because of the large volume of debris it carried. However, high water marks at the streamgaging station showed the flow to have reached a height of 8 feet and a width of 28 feet, or a cross sectional area of 224 square feet. Thus about one-fiftieth as much water from a high-intensity rain caused a discharge of mud, rock, and water about 100 times that from the melting of a record snow pack.

Water conservation study initiated.--Records from a series of 16 runoff plots having aspen forest, shrub, and herbaceous types of plant cover over a period of 15 years have shown that a minimum of about 65 percent of the ground surface must be covered by plants and litter to prevent accelerated erosion and potentially dangerous storm runoff. This minimum protection standard was developed from plots that had not been subjected to grazing. Two important questions remain to be answered about the herbaceous range type that occurs intermingled with patches of aspen and brush on the steep slopes of northern Utah mountains. These questions are: (1) what are the minimum cover conditions required for protection under the impact of grazing use? (2) To what extent do those cover conditions affect the yield of water as seepage flow?

Last year, four replicate areas in the Davis County Experimental Watershed were cleared and seeded to grass as the first step of a plot study of the effects of herbage removal on storm flow runoff, erosion, evapo-transpiration losses, and water available for stream flow. It is planned to install the plot equipment and begin measurements in 1953.

Know your watersheds.--Two publications were prepared and released for general information purposes during the year. One, "Intermountain Watershed Management Highlights," was intended primarily for in-Service training. The other was a "Visitor's Guide" to facilitate the handling of the large number of show-me trips over the Davis County Experimental Watershed.

Boise Research Center

During the past year, steps were taken toward extending research into the problem of maintaining soil stability on steep granitic slopes subject to the disturbance of cutting and logging ponderosa pine. This problem has grown in seriousness in recent years especially in southern Idaho. There, logging operations have been forced into more remote and steeper lands in the headwaters of the Boise, Payette, and Salmon River Watersheds for which there are no reliable protection standards. Research was also continued on several aspects of a soil stability problem on the spring-fall grassland range.

Trampling disturbance effects.--Previous studies have shown that a minimum of 70 percent of the ground surface of the granitic soil-grassland range in the Boise locality is necessary for soil stability and control of storm runoff, under conditions of no livestock grazing disturbance. Last year a study was completed of the effects of artificial trampling disturbance on storm runoff and erosion. In this study 150 infiltrometer plots were disturbed by strikes of an iron "hoof" to simulate various intensities of livestock trampling.

The trampling disturbance decreased the average covering of plants and litter on the ground surface and also enlarged the size of the bare soil openings between the plant and litter patches. The amount of these changes in the soil covering increased significantly with increased degree of trampling disturbance. The amount of surface runoff and erosion also increased significantly over that from undisturbed plots with increased intensity of disturbance.

When subjected to trampling that disturbed 10 percent of the ground surface, none of the wheatgrass or cheatgrass sites having a predisturbance ground cover of 70 percent or more yielded appreciably more runoff or erosion than comparable undisturbed sites. A 20-percent disturbance on sites having an initial plant and litter of 70 to 75 percent resulted in twice as much runoff and erosion than from undisturbed sites. A 40-percent disturbance on sites having as much as 80- to 85-percent initial ground cover resulted in runoff and erosion far in excess of the amounts from undisturbed sites. Under the impact of 60-percent disturbance, all of the sites having less than a 90-percent initial ground cover produced excessive runoff and erosion. These tests provided a basis for establishing tentative limits of tolerable grazing disturbance for the wheatgrass and cheatgrass range lands in the Boise area (Table 5).

Table 5.--Initial amounts of ground cover and sizes of bare openings required for protecting wheatgrass and cheatgrass range lands subject to different levels of trampling disturbance

Trampling disturbance	Wheatgrass		Cheatgrass	
	Minimum ground cover	Maximum bare soil opening	Minimum ground cover	Maximum bare soil opening
(Percent)	(Percent)	(Inches)	(Percent)	(Inches)
0	70	4.0	70	2.0
10	70	2.5	70	1.6
20	80	1.6	80	1.3
40	90	1.0	90	1.2
60	90	1.0	90	1.2

Based on the tentative guides furnished by this artificial trampling disturbance study, a sheep allotment and a cattle unit on the Boise National Forest were selected during the past year for studying the effects of actual grazing use on watershed cover conditions. Field study techniques were developed with a view toward carrying out tests in 1953 and 1954.

Seedling survival.--Attempts to revegetate depleted grassland ranges on the steeply sloping, granitic foothill lands of the Boise River Watershed have been largely unsuccessful to date, especially on south-facing slopes. Inability of seedlings to survive the first year is believed to be due to inadequate soil moisture.

Last year a final check was made on the survival of stiffhair wheatgrass seedlings following two growing seasons. The records show there was 100-percent mortality in the first year on sites where no effort was made to suppress competing vegetation. There was 5-percent survival where all competing vegetation was removed before and after seeding.

Though the mortality figures are discouraging, other findings of the study provide a potential clue to possibly greater success. First, where no competing vegetation was removed the soil dried out to the wilting percentage at a faster rate and to a greater depth than where all competition was removed. This corroborates other tests that removal of competing vegetation is an aid to artificial revegetation. Secondly, as long as the roots of the seedlings continued to grow downward in advance of the lowering level of available moisture, survival was prolonged. This points to the need for a perennial plant that is capable of making rapid root growth in the seedling stage or of withstanding a long period of dormancy during the summer months (Table 6).

Table 6.--Average depth of root growth, depth of soil moisture wilting percentage, and mortality of stiffhair wheatgrass seedlings

Site treatment	Measurement dates	Max. root depth: Live plants	Max. root depth: Dead plants	Depth of wilting percentage	Seedling mortality
		(Inches)		(Inches)	(Percent)
All competing vegetation removed and weeded	7/10/51	18	14	16	31
	7/23/51	20	17	18	51
	8/6/51	24	19	20	63
	8/17/51	28	21	25	73
	8/13/51	29	22	26	80
	9/20/51	30	27	30	95
	8/12/52	--	--	--	95
No competing vegetation removed or weeded	7/10/51	19	15	18	55
	7/23/51	21	18	31	95
	8/6/51	21	19	35	99
	8/17/51	--	21	37	100
	8/13/51	--	--	39	100
	9/20/51	--	--	45	100
	8/12/52	--	--	--	100

Logging disturbance study.--During the past summer twenty watersheds of from 9 to 77 acres in size were selected in the Boise Experimental Forest to test the effects of harvest cutting and logging ponderosa pine on sediment production. This study will be carried out in cooperation with the Division of Forest Management Research and a private cooperator. The watersheds were so located within cutting compartments as to provide a test of the following treatments:

Large caterpillar tractor logging	No. of watersheds
Low reserve cut	4
High reserve cut	4
Small tractor and horse logging	
Low reserve cut	4
High reserve cut	4
No cutting or logging	4

Some preliminary phases of the study were carried out during the year. A detailed survey was made of the present erosion conditions on all of the watersheds. Debris basins were installed on two of the watersheds to test the suitability of the design during the 1953 snow melt season.

PROGRAM FOR 1953

Great Basin Research Center

1. Complete a comprehensive report on the A and B watershed study.

2. Analyze stream flow behavior of the Lefthand Fork and Alpine Cattle Pasture watersheds to determine their suitability for testing effects of treatment.

3. Complete laboratory and analysis phases of exploratory study of effects of range species on evapo-transpiration losses.

4. Continue new phase of the Area A and B watershed experiment and supplemental climatic and stream flow records.

Wasatch Research Center

1. Initiate cooperative study of the change in vegetation on two experimental watersheds.

2. Revise Visitor's Guide for the Davis County Experimental Watershed.

3. Analyze summer storm and flood relations on experimental watersheds and continue related climatic network.

4. Complete installation and initiate measurements on new study of effects of herbage removal on runoff and water losses.

5. Analyze stream flow records on comparative watersheds and continue calculation of discharges from old records.

6. Continue Parrish Plot study.

Boise Research Center

1. Complete reports on (a) seedling survival study, (b) evapotranspiration study, (c) nitrogen loss from granitic soil grassland, and (d) Intermountain infiltrometer.

2. Initiate grazing disturbance study.

3. Complete initial phases of cooperative logging disturbance study.

4. Revise plan in cooperation with the regional office for observational survey of logging practices and participate in survey.

FOREST MANAGEMENT RESEARCH

The forest resources of the Intermountain region are not readily apparent to those visitors who travel the rail routes and highways. But at elevations above the desert valleys, where precipitation is greater and soil more suitable, there is an impressive volume of ponderosa pine, Douglas-fir, lodgepole pine, Engelmann spruce, alpine fir, larch, and aspen. Revised estimates of forest inventory in certain parts of the region are currently indicating volumes well in excess of previous appraisals. Increased demand for timber products, closer utilization, more efficient extraction methods, access roads, increased transportation efficiency, regional population increase, the scarcity of timber on state and private land--all have recently spurred the business of forest management. There is the strong likelihood that this trend will continue which, in turn, underscores the desirability for forest management of a high order and the pressing, obvious need for an accurate inventory of forest resources for the entire region, a region which imports more than it exports. Because water supply and its regulated flow are vital to the welfare of the people, and because mountain forage for stock is depended on by industry, the silviculture required for successful wood production must be harmonized with these other important uses of the forest.

From the standpoint of available volume and value of products cut, ponderosa pine and its chief associate Douglas-fir, can be considered the most important forest type in the region. Lodgepole pine is probably next in consequence for the area as a whole. The bulk of ponderosa pine is situated in south-central Idaho where excellent stands of this species can be found in the rough topography which characterizes the forest sites of the region. The mountainous terrain, the loose granitic soil, the low annual precipitation, and the short growing season, all combine to present a formidable but challenging task to the forest manager. While infrequent seed crops, insects, and disease aggravate his problems, he must turn to the silvical facts and results of research to guide him successfully.

The extensive stands of lodgepole pine in southeastern Idaho and western Wyoming provide an impressive reservoir of wood. With pulpwood from adjacent areas being shipped to the distant Lake States, and the national consumption of this species evidently rising, who can doubt that the time will come when the extensive lodgepole stands will be drawn upon for pulpwood from either within or without the region? But as with ponderosa pine, the knowledge upon which forest manipulation must be based, is meager and fragmentary and relies only on studies elsewhere which are by no means entirely applicable.

The greatest need in forest management in the Intermountain region is a knowledge of those measures which will keep the ponderosa and lodgepole pine stands and their associated species at a high level of productivity. Specifically, how should the various stands in these types be cut to insure maximum high quality net growth and prompt and sufficient regeneration to sustain production? It is in this direction that the efforts of forest management research at Intermountain are being exerted to find solutions to the problems and develop applicable guides for the forest manager.

THE YEAR'S ACCOMPLISHMENTS

Ponderosa pine.--Progress in the installation of the methods-of-cutting study in Idaho was sustained. This involved the cruising of all stems 11.00 inches and over on some 300 acres in the Boise Basin Experimental Forest; the establishment of 205 "hubs" as centers for tallying the smaller sized stems, permanent growth record trees, and a record of stocking; the composing of stand and stock tables for each of 8 compartments comprising the first replication; and the marking of timber to be cut by risk selection and groupwise selection on 8 compartments or 445.0 acres.

The viability tests of seed lots from 1937 and 1950 crops of Douglas-fir started in 1951 were continued and completed. The 1937 seed showed virtually no germination but the 1950 seed showed a germinative capacity of 54 percent for unstratified seed and 78 percent for stratified (45 days in moist sand at temperatures close to 38° Fahrenheit). Stratification increased germinative energy since 76 percent of the stratified seed germinated within 25 days while almost 30 days elapsed before germination started in unstratified seeds.

Lodgepole pine.--Through the cooperation of Administration, a start was made in 1952 toward appraising the potentialities of lodgepole pine in the Intermountain region. Inspections of stands and operations made on 12 national forests in the region and in Montana and Colorado provided the required information to prepare a problem analysis defining the nature and scope of lodgepole pine management problems and their possible solutions. Past and current research in lodgepole pine by the Rocky Mountain, Northern Rocky Mountain, and Pacific Northwest Forest and Range Experiment Stations was reviewed to avoid duplication of effort when an active research program is launched at the Intermountain Station.

An immediate outcome of the problem analysis, which was virtually completed, is a bibliography of lodgepole pine comprised of some 300 references. This is to be published in 1953 as a Station paper and should be useful to others engaged in research on this widespread species.

Forest survey --During the calendar year 1952 this forest survey office has continued to function in a liaison capacity between this Station, the Northern Rocky Mountain Forest and Range Experiment Station, and Region 4.

Forest survey crews from the Northern Rocky Mountain Station and cooperating crews from Region 4 completed inventory field work on 6.2 million acres of land in southwestern Idaho. Of this area, approximately 2.0 million acres were forest land making a total area of some 3.4 million acres of forest land in south Idaho covered to date. This inventory field work consists of type mapping of forest land and measurement of semipermanent, volume sample plots. Office compilation is approximately 50 percent completed and type maps for about 30 percent of the forest land are in the final drafting stage.

The Station also collaborated with the California Forest and Range Experiment Station in a census of lumber production in 1951 for the State of Nevada. This Station collected the production statistics and the California Station will release the data in a publication covering combined lumber production figures for the States of California and Nevada for the year 1951.

During the past year the forest survey office has also collaborated with Region 4 in reviewing Timber Resource Review task plans and in the preparation of regional plans for various phases of the Timber Resource Review.

PROGRAM FOR 1953

Ponderosa pine.--Complete the measurement installation of the methods-of-cutting study by cruising, installing hubs, and marking on the 8 compartments comprising the second replication. It is also planned to log the 8 compartments of the first replication measured in 1952. This work will complete the major part of installation of the experiment as far as measurements are concerned.

Lodgepole pine.--A program for lodgepole pine research is suggested in the problem analysis for consideration by Administration. Acceptance or modification of the studies set forth in this program will determine specifically which studies will be undertaken first. Because so little is known about Intermountain lodgepole stands there is likelihood that any active research program in 1953 will stress first the collecting of silvical and mensurational data which could be used to evaluate the effect of past cutting in present stands. With a limited research staff this appears to be the most logical approach to setting up tentative guides for lodgepole pine management until more detailed studies can be carried out.

Forest survey.--Forest survey inventory field work is expected to be completed on an additional 2 million acres of forest land in southwestern Idaho, principally on the Payette National Forest. It is planned to complete office compilation for the area covered in the field in 1951 and 1952 and to carry forward compilation from field data collected in 1953.

This forest survey office plans to carry on the bulk of the work for the Timber Resource Review Task V--Timber Cut and Wood Utilization--and to assist Region 4 in preparing plans for carrying out Tasks VI and VIII.

An item of considerable importance to be taken up early in 1953 is the matter of revising and extending the present three-way cooperative agreement to cover forest survey activities throughout the remainder of Region 4.

RANGE ECONOMICS

The Intermountain region, as designated by the Forest Service, supports 1,329,000 people. The land area of 179,189,720 acres in 1950 furnished feed for 1,044,454 beef cows and 2,445,165 sheep. The water flowing off these lands is estimated to total 30,665,000 acre feet annually.

The national forests have an important productive role in the economy of this region. The 30,642,628 acres of national forest provided grazing for 307,360 beef cows and 1,391,377 sheep in 1950 The water yield of national forest lands is estimated to be 24,900,000 acre feet annually. These lands produce much of the big game forage, and supply hunters with two-thirds of the mule deer and one-half the elk that they take each year. The national forests are also important in the production of timber crops, supplying a third of the value of the annual harvest of timber products. Sustained production of lumber, the livelihood of many communities, is dependent on the national forest which contain four-fifths of the remaining saw timber volume of this region.

Research that benefits national forest management also directly benefits people and communities.

Problems for economics research

Range improvements of various kinds have been installed by ranchers and public agencies and more are planned for the future. Among the improvements and management practices of current interest are range revegetation, eradication of undesirable plants, changes in the intensity of grazing use, installation of physical improvements such as fences and water developments, water hauling on the range, and transportation of livestock between seasonal ranges. Although much information is now available on how to do range improvement work and what results can be expected, relatively little information is available on the economic benefits, costs, and aspects of management. It is desirable to know under what conditions the added income from various range improvements exceeds costs, the incidence of income and costs, the effects on other phases of management, the economic obstacles to installation of new improvements and practices, and means available to overcome these obstacles.

Wild lands are managed to provide people with the things they need and want: livestock products, timber, water, wildlife, and recreation. Lands are used to produce values, in terms of money or in a broader, often intangible, sense. As human populations change and as their needs and desires change, the management of wild lands must be adjusted to meet the changes. Often a management change requires a long period of time, and land uses cannot easily be shifted, for example, from a heavily grazed range to a timber-producing watershed. The management changes made now may become effective many years from now, so the better the estimate of the future, the better will be the present management adjustment. Economics research can improve the land manager's estimates of the future situation by analyzing the factors that cause human needs and desires to change; by compiling, scrutinizing, and drawing inferences from data on human population, prices and costs, industrial trends, agricultural production, range condition and trend, and relations between the multiple uses of wild lands.

Wildland administrators are interested in the money income likely to be received from the production of meat and wool, timber, water, and game animals, and from the environment that attracts recreationists. Although money income is only one of the many considerations that directs management of wildland areas, it is an important consideration and one in which research is needed. Research may help develop techniques for economic evaluation of multiple-use products. Economics research can aid in developing techniques for estimating income and cost so that every expenditure may be used in a way that will bring the greatest return.

Explorations in multiple-use economics

Research designed to assist multiple-use management was carried forward during the year. As a first step in developing economic aids to management, net direct money income from a combination of two land uses, water production and livestock grazing, was selected for study.

Water and livestock forage are two important range land products that are often on the same land unit and require changes in management to favor one or the other. Sometimes the adjustments are difficult to make, part of the difficulty being due to lack of information on what the economic effects of the adjustments are likely to be. Research and experience have accumulated a considerable store of knowledge about the physical and biological aspects of water production and livestock grazing. Commensurate progress is desirable on the economic side.

The investigation of net direct money income deliberately leaves out other phases of income from wildland production, which are net indirect money income and intangible returns. Net direct money income is received by the people engaged in converting wildland products into a form directly usable by consumers. The net direct money income from livestock grazing, for example, is received by ranchers, their employees, and investors in the ranch business. In timber production the comparable income accrues at the sawmill, in water production usually at the farm. In wildlife and recreation activities net direct money income is received by the business firms engaged in "converting" big game and scenery into meat and enjoyment, including, for example, dude wranglers and resorts.

Net indirect money income is received by the people servicing the recipients of the direct income, and those engaged in further handling of the wildland products, including wholesalers and retailers. Intangible returns cannot be given a money value, but, nevertheless, they frequently have an important place in land-use decisions. Investments in recreational improvements, for example, may be made because people generally want them and place high intangible values on recreational activities.

Net direct money income from water and livestock forage production may be estimated by use of principles that have been developed in national income accounting. When the income changes from proposed land-use adjustments, such as reductions in grazing to favor water production, are estimated, decisions can be made that are likely to increase income. Without such estimates land-use adjustments may be detrimental rather than beneficial, a loss in grazing income may offset the gain in water income.

Community income accounts were tried on a sample range-watershed in this region. Three land-use situations were assumed: (1) the present, (2) the future with presently planned adjustments carried out, and (3) the future with adjustments aimed at increasing net direct money income only.

The results of this analysis indicate that, insofar as possible, each proposed management practice and physical improvement should be analyzed as to expected returns and costs. The unit for which the analysis is made is a "technologically complete" one, for example, a drift fence that will do the job it is intended for, or a terracing system that will reduce the erosion to the degree considered adequate under existing circumstances. Each of the "technologically complete" physical improvements must show a favorable balance of returns to costs in order to be acceptable for a land-use plan aimed at increasing the net direct money income. (2) Community income is increased when land managers recognize that a watershed has a sustained yield capacity which can be developed and which need not be sacrificed in the process of changing land uses. (3) Community income is increased, when, as a result of the returns-cost analysis, management expenditures are made on the basis of what each expenditure returns in net direct money income, rather than on the basis of the apparent total money value of the resource upon which the expenditure is made. Water production values, for example, usually exceed grazing values, but, nevertheless, grazing expenditures may bring greater returns in many instances.

It is hoped that the community income concept here explored will be adaptable to the many and complex evaluation problems in multiple-use wildland management.

Miscellaneous economics activities

Several requests for economics information were answered during the year. Reports were prepared on livestock and big game and on size of livestock permits in Utah. In cooperation with other technicians data were compiled and a report prepared on land areas and uses, agricultural production, and the national forest contribution to regional economy. Technical discussions covered subjects such as range types, land valuation, taxation, range use, price-cost data and index numbers. Manuscripts involving economics information were reviewed. Assistance was rendered to the Western Agricultural Economics Research Council in planning regional research in the economics of range land improvement. Participation was continued in activities of the Society of American Foresters and the American Society of Range Management

PROGRAM FOR 1953

The work already begun in the economics of multiple-use management will be continued with the objective of preparing a Station publication during the year.

FLOOD CONTROL SURVEYS

The work of the Flood Control Survey Division was severely curtailed during the last half of the year because of a large reduction in funds appropriated for surveys and river basin planning. This reduction, amounting to about 60 percent at the Intermountain Station as compared to the previous year made it necessary to immediately reduce the division staff by about two-thirds.

Realignment of work plans and yearly goals as imposed by this situation resulted in the postponement of all work on new surveys, concentration on completion of flood control phases of the comprehensive agricultural programs for the Columbia and Arkansas-White-Red River Basins, and the revision of survey reports previously submitted to the Secretary of Agriculture.

One of the most important effects of this situation was that the Station was forced to suspend all survey investigations in the Colorado River Basin. This was unfortunate because of the urgent need for a planned study of flood and sediment problems and their solution in that basin.

An important facet of this problem is that the multi-million dollar Colorado River storage project, embodying a comprehensive program of additional reservoirs, power development, and irrigation in Upper Colorado Basin, has progressed through several essential stages and it appears that the project proposal may soon be presented to the Congress for consideration. If maximum long-time benefits are to be obtained from the existing and proposed river developments it is vital that no time be lost in developing a comprehensive agricultural program which would include range and forest lands designed to check accelerated erosion now producing sediment at a rate which, if unchecked, presages a relative short life of existing and proposed water developments and the economy which they support. Such a program is also needed to aid in restoring the productivity of forest and range lands.

In order to meet committed obligations in the Columbia and Arkansas-White-Red River Basins with a much reduced staff, a considerable amount of scaling down of planned detail was required. Status of this work at the end of the year indicated the job assignments would be met without delaying other phases of the survey but results will be available in a rather generalized form with considerable elimination of supporting detailed studies.

Accomplishments during 1952 with respect to pending survey reports are briefly summarized as follows:

1. The survey report on the Sevier Lake (Utah) Watershed was accepted by the Committee on Public Works of the House of Representatives and printed as House Document No. 406, 82nd Congress, 2d Session "Sevier Lake Watershed Utah."

2. The Fountain River (Colorado) survey report was transmitted by the Secretary of Agriculture, the State of Colorado, and member agencies of Federal Inter-Agency River Basin Committee for review and comments. Following receipt of comments and the resolution of questions raised by the State of Colorado the survey report was submitted to the Bureau of the Budget and to the Committee on Public Works.

3. Further revision of the Boise River (Idaho) report was completed late in the year and in December the report was approved by the Secretary of Agriculture and transmitted to the State of Idaho and the member agencies of FIARBC for review and comment.

4. Final field draft of the survey report on the Virgin River (Nevada, Utah, and Arizona) Watershed was completed in January. Review by the field offices of other Federal bureaus and departments was completed. At the close of the year the report was being reviewed by the office of the Secretary of Agriculture.

5. The survey report on the Wasatch Front (Utah) Watershed was approved by the Secretary of Agriculture in January and submitted to the State of Utah and member agencies of FIARBC for review and comments. Minor revision was required to answer certain comments and at the close of the year the survey report was under consideration by the office of the Secretary.

6. Revision of the flood control phases of the supplemental report on the South Platte Watershed (Missouri River Basin) was completed early in the year and additional assistance was given to the Soil Conservation Service in revision of similar supplemental reports covering the Big Blue and Salt-Wahoo Watersheds in Nebraska and Kansas. This supplemental report together with several others received Departmental approval and was transmitted to the Committee on Public Works.

Other tasks completed during the year include:

1. An investigation of the relation of land and cover condition to snow melt runoff and erosion during the serious flood which occurred along the Wasatch Front in the spring of 1952.

2. Participation on a number of committees established to develop specific phases of the comprehensive surveys of the Columbia and Arkansas-White-Red Basins.

3. Preliminary investigations and negotiations with local people relating to flood problems in the Truckee, Carson, and Las Vegas Watersheds in Nevada.

4. Participation in an interagency joint study set up to analyze the hydrologic effects of a complete program of land treatment measures in the Arkansas-White-Red River Basin.

5. Assistance to Regions 2 and 3 of the Forest Service in revising project work inventories to insure adequate consideration of flood control measures.

PUBLICATIONS

A. Departmental publications

None.

B. Publications in scientific and professional journals, etc.

Blaisdell, James P., A. C. Wiese, and C. W. Hodgson. Variations in chemical composition of bluebunch wheatgrass, arrowleaf balsamroot, and associated range plants. Jour. Range Mangt. 5(5):346-353. 1952.

Curtis, James D. Effect of pregermination treatment on the viability of Ceanothus seed. Ecology 33(4):577-578. 1952.

_______________. It could happen to you! Kiwanis Magazine 37(10):28-29. 1952

_______________. Response to release of ponderosa pine in central Idaho. Jour. Forestry 50(8):608-610. 1952.

_______________. Destruction of paper tree tags by squirrels. Jour. Forestry 50(3):220-221. 1952.

Ellison, Lincoln. Observations on ecological research relating to soil erosion of pasturelands in eastern New South Wales. Jour. Austral. Inst. Agr. Sci., 18(3):147-151, September 1952.

Ellison, Lincoln and C. M. Aldous. Influence of pocket gophers on vegetation of subalpine grassland in central Utah. Ecology 33(2):177-186. 1952.

Houston, W. R. A preliminary study of some factors affecting forage production in the aspen type of central Utah. M. S. Thesis, Univ. of Utah. 1952.

Hutchings, Selar S. Snout moth damage to shadscale in southern Idaho. Natl. Wool Grower 42(7):24-25, 38. 1952.

Julander, Odell. (Book review: American wildlife and plants by Martin et al.) Jour. Range Mangt. 5(3):164-165. 1952.

Marston, Richard B. Ground cover requirements for summer storm runoff control on aspen sites in northern Utah. Jour. Forestry 50(4):303-307. 1952.

Olson, O. C. The soil profile as an aid to range management. Jour. Range Mangt. 5(3):124-128. 1952.

Plummer, A. Perry and Neil C. Frischknecht. Increasing field stands of Indian ricegrass. Agron. Jour. 44(6):285-289. 1952.

Robinette, W. L., Odell Julander, Jay S. Gashwiler, and Justin G. Smith. Winter mortality of mule deer in Utah in relation to range condition. Jour. Wildlife Mangt. 16(3):289-299. 1952.

Smith, Justin G. Food habits of mule deer in Utah. Jour. Wildlife Mangt. 16(2):148-155. 1952.

Tigerman, Merle H. Observations of infiltration rates and sediment production on big game ranges. Jour. Wildlife Mangt. 16(2): 224-225. 1952.

Walters, J. F. [With the sections] Utah. Jour. Range Mangt. 5(3):179-180. 1952.

Wilson, Alvin K. An age-vigor tree classification for Douglas-fir in central Idaho. Jour. Forestry 50(12):929-933. 1952.

C. Miscellaneous processed reports

Craddock, G. W. and R. B. Marston. Intermountain watershed management highlights. Mimeo in-Service pub. 1952.

Julander, Odell. Forage habits of mule deer during the late fall as measured by stomach content analyses. Intermountain Forest and Range Expt. Sta. Research Note No. 2, 5 pp. March 1952.

Mueggler, Walter F. Effects of several chemicals on tall larkspur and associated tailcup lupine. Intermountain Forest and Range Expt. Sta. Research Note No. 4, 3 pp. June 1952.

Staff Intermountain Station. Visitors guide to the Wasatch Experimental Forest. Mimeo. Station release. 1952.

Wilson, Alvin K. Tables for classifying age and vigor of Douglas-fir in central Idaho. Notebook material, unclas. Nov. 1952.

________________. Rodent damage in ponderosa pine plantations. Intermountain Forest and Range Expt. Sta. Research Note No. 3, 2 pp May 1952.

STATION PERSONNEL, C.Y. 1952

ADMINISTRATION

Reed W. Bailey	Director
Irene P. Muir	Secretary (Steno.)
Joel F. Walters	Editor (Forestry)
Walter E. Mann	Administrative Officer
Marguerite A. Israelson	Clerk
Leona H. O'Donnell	Clerk
Lillian Eastman	Clerk-Typist
E. Kenneth Aarestad	Clerk-Typist
Vendla K. Roberts	Clerk-Steno.
Marilyn R. Morris	Clerk-Steno.
Clara S. Sanders	Clerk-Steno.
Harry W. Pledger	Foreman C&M

RANGE RESEARCH

Grazing Management

Lincoln Ellison	Range Conservationist (R)
Odell Julander	Range Conservationist (R)
Selar S. Hutchings	Range Conservationist (R)
James P. Blaisdell	Range Conservationist (R)
Justin G. Smith	Range Conservationist (R)
William J. McGinnies	Range Conservationist (R)
Walter F. Mueggler	Range Conservationist (R)
Walter R. Houston	Research Forester
Adrian E. Dalton	Range Conservationist (R)
Paul E. Hansen	Range Aid (Research)
Evan R. Johnson	Clerk-Steno.

Range Reseeding

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Alvin T. Bleak	Range Conservationist (R)
Neil C. Frischknecht	Range Conservationist (R)
Ralph C. Holmgren	Range Conservationist (R)

FOREST AND RANGE ECONOMICS

J. O. Lammi	Forest Economist (Resources)

Forest Survey

Melvin E. Metcalf	Forest Economist (Resources)

FOREST AND RANGE INFLUENCES

George W. Craddock	Forester (Forest Influences)
Paul E. Packer	Forester (Forest Influences)
Richard B. Marston	Forester (Forest Influences)
Howard K. Orr	Forester (Forest Influences)
Lawrence V. Monninger	Forester (Forest Influences)
Harold F. Haupt	Forester (Forest Influences)
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FLOOD CONTROL SURVEYS

Henry L. Lobenstein	Forester (Forest Influences)
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J. Marvin Rosa	Hydrologist
Albert R. Blanch	Forester (Forest Influences)
Harold H. Price	Forester (Forest Influences)
William E. Murray	Forester (Forest Influences)
Byron F. Thurmond	Cartographic Engineer

FOREST MANAGEMENT

James D. Curtis	Forester (Forest Mangt. Research)
Alvin K. Wilson	Forester (Silviculture)
David Tackle	Forester (Silviculture)